His Majesty's Government of Nepal

MINISTRY OF PHYSICAL PLANNING AND WORKS

DEPARTMENT OF ROADS

STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE WORKS

ASAD, 2058/JULY, 2001

SECTION 100 – GENERAL

SECTION 100 – GENERAL

101. OFFICES FOR ENGINEER

The Contractor shall provide and maintain offices for the use of the Engineer and his staff if provided in the contract.

102. ACCOMODATION OF TRAFFIC

(1) Scope

This Clause covers the construction and maintenance of the necessary detours and diversions, barricades and signs, and everything necessary for the safe and easy passage of all public traffic during the construction period and also the removal of diversions as they become redundant including bringing up the area use into its original condition.

The Contractor shall take precaution regarding safety at road works. The Contractor shall strictly adhere to the stipulations of the latest publication of the document "SAFETY AT ROAD WORKS: A Code of Practice for Signing at Road works" published by the Traffic Engineering and Safety Unit of the Design Branch of the Department of Roads.

(2) General Requirements

The Contractor shall at all times carry out works on the road in a manner creating least interference to the flow of traffic. For all works involving improvements of the existing road, the Contractor shall provide and maintain a passage for traffic either along a part of the existing carriageway under improvement, or along a temporary diversion constructed close to the road. The Contractor shall take prior approval of the Engineer regarding traffic arrangements during construction.

The Contractor may be allowed to stop traffic temporarily. The period of such closure shall be as agreed by the Engineer at lest 14 days in advance, to enable the Engineer to issue the relevant notices.

(3) Temporary Diversions

(a) Provisions of Diversions

Where some portions of the existing road cannot be used by through traffic, diversions as may be required to deviate traffic from such portions shall be constructed

(b) Survey Beacons and Monuments

Diversions shall be constructed so as not to damage or displace trigonometrical survey beacons and road monuments. In exceptional cases where this is not possible, arrangements shall be made to have survey beacons suitably referenced before they are displaced and relocated after the completion of the work.

(c) Access to Properties

Access to properties which fall within or adjoining the area over which work is being carried out shall be provided in the manner as existed before the start of the work.

(d) Temporary Works

If diversions are provide they shall include the construction of temporary gates , grid gates, fences, drainage works, and other incidentals considered necessary.

(e) Public Services

Arrangements shall be made for the continuity of all public services such as power lines, telephone lines, water mains, sewerage, drainage etc., if the existing services are likely to be affected.

(f) Width of Diversions

The usable width for accommodation of two-way traffic shall not be less than 6 m. Where diversions consist of two separate one-way lane the minimum usable width of each lane shal not be less than 3.5 m.

(g) Temporary Drainage Works

All necessary temporary drainage works required for proper surface run-off, such as side drains, catchwater drains, temporary cross-drainage structures, etc. shall be constructed.

(h) Earthworks for Diversion

Diversions shall be shaped and graded making full use of all material that can be sufficient material cannot be obtained in this manner, material shall be imported from other sources. Where necessary, cuttings shall be made to obtain a satisfactory vertical alignment. All necessary clearing including the removal of all trees and stumps shall be performed. Where the sub-grade is not sufficiently compacted in its natural condition, it shall be compacted as specified in Section 900 prior to the commencement of the earthworks.

All fill material shall be compacted to a density of at least 90% of maximum dry density (Heavy Compaction).

(i) Maintenance of Diversions

All diversions shall be maintained in a safe and smooth trafficable condition. Whenever required the diversions shall be bladed by means of graders to provide a smooth riding surface free of corrugations. All potholes shall be promptly repaired. Diversion shall be watered to keep down dust from traffic and in order to facilitate the proper blading of the surface. All drainage works shall be maintained in good working order and kept unblocked.

(j) Removal of Diversions

When traffic is routed permanently onto the new road following the completion of construction, the diversions which are no longer required shall be removed and the ground reinstated to its original condition.

(4) Accommodation of Traffic Where the Road is Constructed in Half Widths

Where by reason of difficult terrain or for any other reason, the construction of diversions is not possible, the road shall be constructed at the time. The lengths of the half width for construction shall be kept to a minimum, with a provision for traffic traveling in opposite directions to pass at frequent intervals.

The works in one half width of the road shall be so arranged that the traffic will have free one-way movement in another half during construction period. That half of the road which is being used for traffic, shall be maintained free of corrugations and potholes.

Wherever possible the Contractor shall ensure that the whole road width is open at night. Should the road not be in a safe trafficable condition for two-way traffic over the whole width, at the end of each day's work the Contractor shall adequate flagmen, signs, barriers, and the necessary staff at his own cost to ensure a reasonable free flow of traffic alternately in each direction.

Materials and equipment stored on, or adjacent to the existing roadway shall be so placed and the work at all times shall be so conducted, as to cause no obstruction of the traveling public and traffic.

(5) Traffic Safety and Control

The Contractor shall provide, erect and maintain such barricades, including signs, markings, flags, lights and flagmen as may be required for the information and protection of traffic approaching to or passing through the section of the road under improvement and/or diversions. Barricades, traffic signs and warning boards shall be provided as per the **Traffic Signs Manual (Latest Publication)** published by the Traffic Engineering and Safety Unit of the Design Branch of the Department of Roads.

The barricades erected on either side of the carriageway/portion of the carriageway close to movement of traffic, shall be of strong design to resist violation, and be painted as per the said Traffic Sign Manual. On both sides, suitable regulatory and/or warning signs shall be installed for the guidance of the road users. On each approach, at least two signs shall be put. The location of these signs shall be in accordance with the Code of Practice published by the Traffic Engineering and Safety Unit of the Department of Roads (Latest Publication).

In some locations steel drums may also be placed. These drums shall be whit-washed, blasted with sand and provided with retro reflective tape strips, red on the left hand side facing on coming traffic and white on the right hand side as appropriate. The minimum size of these tapes shall be 0.01 sq.m. The drums shall be maintained in a clean and effective condition and no stones or any other warning device shall be placed on top of the drums

(6) Measurement and Payment

Unless otherwise provide n the contract, no separate measurement and /or payment shall be made for all materials and works required under this Clause. All costs in connection with the work specified herein shall be considered to be included with other related items of the work in the Bill of Quantities.

103. PUBLICLY AND PRIVATELY OWNED SERVICES

(1) If any privately owned service for water, electricity, drainage, etc., passing through the site is affected by the works the Contractor shall provide a satisfactory alternative service in full working order to the satisfaction of the owner of the services and of the Engineer before terminating the existing service.

(2) Drawing and scheduling the affected services like water pipes, sewers, cables, etc. owned by various authorities including Public Undertakings Local Authorities included in the contract documents shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

(3) Notwithstanding the fact that the information on affected services may not be exhaustive, the final position of these services within the works shall be supposed to have been indicated based on the information furnished by different bodies and to the extent the bodies are familiar with the final position. The Contractor must also allow for any effect of these services and alternatives upon the works and for arranging regular meetings with the various bodies at the commencement of the contract and throughout the period of the works in order to maintain the required co-ordination. During the period of the works, the Contractor shall agree if the public utility bodies vary their decisions in the execution of their proposals in terms of programme and construction, provided that, in the opinion of the Engineer, the Contractor has received reasonable notice thereof before the relevant alternations are put in hand.

(4) No clearance or alternations to the utility shall be carried out unless ordered by the Engineer.

(5) Any services affected by the works shall be restored immediately by the Contractor who must also take all measures reasonably required by the various bodies to protect their services and property during the progress of the works.

(6) The Contractor may be required to carry out the removal or shifting of certain services/utilities on specific order from the Engineer for which payment shall be made to him. Such works shall be taken up by the Contractor only after obtaining clearance from the Engineer and ensuring adequate safety measures.

(7) No separate measurement and payment shall be made for the work of temporarily supporting and protecting the publicly and privately owned services and/or for construction and maintenance of new services in lieu of them.

104. SURVEY AND SETTING OUT

(1) During the period of Commencement of works the Contractor shall resurvey the Base Lines, Traverse Point, Bench Marks and confirm the co-ordinates and levels of the stations. He shall immediately notify the Engineer of any discrepancies and shall agree with the Engineer any amended values to be used during the contract, including replacements for any stations missing from the original stations.

(2) The Contractor shall check, replace and supplement as necessary the station points and agree any revised or additional station details with the Engineer.

(3) All stations and reference points shall be clearly marked and protected to the satisfaction of the Engineer.

(4) Where a Station Point is likely to be disturbed during construction operations, the Contractor shall establish suitable reference stations at locations where they will not be disturbed during construction. No old station shall be covered, disturbed or destroyed until accurate reference stations have been established and details of such stations have been approved by the Engineer.

(5) The Contractor shall establish working Bench Marks tied with reference stations soon after taking possession of the site. The coordinates and the elevations of the reference stations shall be obtained from the Engineer. The working Bench Marks shall be at the rate of four per kilometer and also near all major/medium structure sites. Regular checking of these Bench Marks shall be made and adjustments, if any, got agreed with Engineer and recorded.

(6) The Contractor shall be responsible for the accurate establishment of the center lines based on the Drawing and data supplied. The center lines shall be accurately referenced in a manner satisfactory to the Engineer. The reference points shall be established at every 30 m interval in plain/rolling terrain and 10 m interval in hill terrain, with marker pegs and chainage boards set in the right of way. A schedule of reference dimensions shall be prepared and supplied by the Contractor to the Engineer.

(7) The existing profile and cross-sections shall be taken jointly by the Engineer and the Contractor. These shall form the basis for the measurements and payments. If in the opinion of the Engineer, design modifications of the center lines and/or grade are advisable, the Engineer shall issue detailed instructions to the Contractor and the Contractor shall perform modifications in the field, as required, and modify the levels on the cross-sections accordingly.

(8) Accurate control of lines and levels shall be provided by the Contractor at all stages of the construction. In respect of roads itself, control shall be at least 10 m interval or such close interval as may be directed by the Engineer. The lines and levels of formation, side slope, drainage works, etc. shall be carefully set out and frequently checked. Care shall be taken to ensure that correct gradients and cross-sections are obtained everywhere. Wherever necessary, but particularly on completion of the subgrade, subbase and the base, the Contractor shall re-establish center line pegs at sufficiently close intervals to determine the edges of base and surfacing accurately.

(9) The Contractor shall provide the Engineer with all necessary assistance for checking the setting out, agreement of levels and any other survey or measurement which the Engineer needs to carry out in connection with the contract during the entire period of contract. Such assistance shall include:

(a) provision of suitably qualified surveyors to work under the direction of the Engineer as required.

(b) provision of all necessary support for these surveyors ncludingassistant, chainmen, labours, handtools, pegs an materials.

(c) provision of survey equipment (Precision automatic levels, theodelite and distomat) as required by the Engineer for survey works

No separate measurement and/or payment shall be made for the work required under this Clause. All costs in connection with the work specified herein shall be considered included in the related items of the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities

105. ACCESS TO ABUTING PROPERTIES

For the duration of the works the Contractor shall at all times provide convenient access to paths, steps, bridges or drives for all entrances to property abutting the site and maintain them clean, tidy, and free from mud or objectionable matter.

106. DIVERSION BRIDGES

(1) Temporary diversion bridges shall be provided by the Contractor as required by the contract. Where the Contractor is required to prepare Design, Drawing and Specifications of the structure, he shall submit his proposal shall be accompanied with sufficient ground and hydraulic information to enable the Engineer to decide on the stability of the structures.

(2) The Contractor shall maintain the temporary bridges in a condition satisfactory to the Engineer so long as required.

(3) On completion of the works, the Contractor shall obtain the approval of the Engineer before removing the temporary bridges. The materials arising from the removal shall become the property of the Contractor or of the Employer as designated in the contract. In the case of the materials becoming the property of the Employer, they shall be removed to the Employer's premises and neatly stacked at no cost to the Employer.

(4) Measurement and Payment

Construction and maintenance of diversion bridges for the required period quantified in months shall be paid as per contract price on lump sum basis. Alternatively, if specified in the contract, construction of the diversion bridges shall be paid as per contract unit rates of respective items and maintenance work shall be paid as per days work provided in the Bill of Quantities. The contract price and/or rates shall be the full and the final compensation to the Contractor as per Clause 112.

107. MAINTENANCE OF ROAD

(1) The Contractor shall be responsible for undertaking all routine maintenance of the existing road and all bridges on the road from the day the road is officially handed-over to the Contractor until the issue of Defects Liability Certificate by the Engineer. The Contractor shall also carry out all the routine maintenance of the completed works from the time of their substantial completion until the Defects Liability Certificate is issued.

The Contractor shall also maintain roads that he uses for construction or access and the use of such roads shall be identified in advance to the Engineer for inspection prior to use.

The routine maintenance of the road shall include besides other, trimming vegetation, cleaning all culverts, ditches, borrow pits, road side drainage, drainage channels and any other obstructions including minor landslide (up to 20 m^3 at one spot, with unlimited number of spots), cleaning road signs and checking and undertaking the repair of guardrails and other road safety structures, cleaning including removal of obstructions on bridge decks and bridge deck drainage elements, checking including and cleaning removal of obstructions on bridge decks and bridge deck drainage elements, checking including removal of obstructions on bridge decks and bridge deck drainage elements, checking and cleaning of expansion joints and bearings, cleaning bearing shelves and weep holes, removing accumulated debris and vegetation around and berween piers and abutments, repairing parapets, clearance on the road to allow free flow of traffic and reinstatement of any damaged or deteriorated carriageway, and protection of adjoining works. In case of road Section where the surface is in badly damaged condition, the maintenance of existing road surface shall be maintained by potholes patching using gravel, reprofiling and regarding as instructed by Engineer. The surface shall be maintained to ensure longitudinal and transverse profile. All the damages to the road carriageway and shoulder shall be repaired with the material of equal or higher standard than the original surfacing.

The Contractor shall perform the maintenance works as often as required to keep the carriageway, shoulders, and adjoining structures in proper working order to the satisfaction of the Engineer.

During the period of commencement of works the Contractor shall mobilize labour and equipment to make an immediate start on the maintenance of the existing road. The location and scope of the maintenance work shall be as directed by the Engineer.

Existing ditches shall, where shown on the Drawing, be cleared by removing vegetation growths and deposits. The sides shall be trimmed throughout and the bottoms uniformlu graded and the ditches kept clean and trimmed and maintained so long as required. Material removed from the existing ditches shall be disposed off at the places as directed by the Engineer.

Should at any time the Engineer gives any instruction for the up keep of a section of the road/site and the Contractor does not respond in 48 hours, the Engineer shall be empowered to instruct others to carry out the works. Any costs involved by this action shall be deducted from any money due to the Contractor.

(2) Measurement and Payment

Maintenance of road in defects liability period quantied in months shall be paid as per contract price on lumpsum basis. Maintenance of road during construction/rehabilitation period quantified in km-months shall be paid as per contract unit rate. The contract price and/or unit rate shall be the full and the final compensation to the Contractor as per Clause 112.

108. NOTICE BOARD

The Contractor shall erect notice boards (1.8m_1.2m) at each end of the site giving details of the contract in the format and wording as directed by the Engineer. These boards shall be erected within 14 days after the Contractor has been given the Possession of Site.

The Contractor shall not erect any advertisement sign board on or along the work without the written approval of the Employer.

All sign boards shall be removed by the Contractor by the end of the Defects Liability Period.

109. ENVIRONMENTAL PROTECTION WORKS

The environment has been defined to mean surrounding area including human and natural resources to be affected by execution and after completion of works.

The Contractor shall take all precautions for safeguarding the environment during the course of the construction of the works. He shall abide by all prevailent laws, rules and regulations governing pollution and environmental protection mitigation measure specified in the Latest Publication of "**Environmental Management Guidelines"** published by the Department of Roads.

The Contractor shall prohibit employees from unauthorized use of explosives, poaching wildlife and cutting trees. The Contractor shall be responsible for the action of his employees.

Environmental protection works, among others, shall also include he following:

(1) Borrow/Quarry Sites

The Engineer shall have the power to disallow the method of construction and/or the use of any borrow/quarry area, if in his opinion, the stability and safety of the works or any adjacent structure is endangered, or there is undue interference with the natural or artificial drainage, or the method or use of the area will promote undue erosion.

All areas suspectible to erosion shall be protected as soon as possible either by temporary or permanent drainage works. All necessary measures shall be taken to prevent concentration of surface water and to avoid erosion and scouring of slopes and other areas. Any newly formed channels shall be backfilled.

Borrows/quarries shall be located away from the population centers, drinking water intakes, cultivable lands and drainage systems. The cutting of trees shall be mimimised. Temporary ditches and/or settling basins shall be dug to prevent erosion. The undesirable ponding of water shall be prevented through temporary drains discharging to natural drainage channels.

Earthwork operations shall be strictly limited to the areas to be occupied by the permanent works and approved borrow areas and quarries unless otherwise permitted by the Engineer. Due provision shall be made for temporary drainage. Erosion and/or instability and/or sediment deposition arising from earthwork operations not in accordance with the Specifications shall made good immediately by the Contractor.

The Contractor shall obtain the permission of the Engineer before opening up any borrows pits or quarries. Such borrow pits and quarries may be prohibited or restricted in dimensions and depth by the Engineer where:

(i) they might affect the stability or safety of the works or adjacent properly;

(ii) they might interfere with natural or artificial drainage or irrigation;

(iii) they may be environmentally unsuitable.

The Contractor shall not purchase or receive any borrow materials from individuals unless the source of such materials has been approved by the Engineer.

At least 14 days before he intends to commence opening up any approved borrow pit or quarry, the Contractor shall submit to the Engineer his intended method of working and restoration. These shall include but not be limited to:

(i) the location, design and method of construction of any access track;

(ii) the volume and nature of materials to be removed;

(iii) the sequence and method of excavation of materials;

(iv) measures for controlling runoff and sediment from the site during operations;

(v) proposals for site restoration including approximate finished levels, drainage, erosion and sediment control, slope stabilization and revegetation, including reinstatement of any access track.

Operations of borrow pit or borrow area shall not be permitted until the method of working for that particular pit or area has been approved by the Engineer in writing. Restoration shall be to the satisfaction of the Engineer.

(2) Disposal of Spoil and Construction Waste

Materials in excess of the requirements for permanent works and unsuitable materials shall be disposed off in locations and in the manner as agreed with the Engineer. The locations of disposal sites shall be such as not to promote instability, destruction of properties and public service systems. Exposed areas of such disposal sites shall be suitably dressed and be planted with suitable vegetation.

The Contractor shall plan his works in such a way that there is no spillage of POL products to the surface or sub-surface water.

(3) Provision and Maintenance of Camps, Offices, Stores, Equipment Yards and Workshops

Various works defined under this item are related to provision an maintenance of camps for workperson and employees, Contractor's site offices, stores equipment yards and workshops. These camps must be adequate, rain-proof, spacious, airy and hygienic with proper lightning and materials storage facilities. The area shall be kept neat and clean.

Space allocated for storage of materials such as cement, gabion wire, reinforcing wire etc. shall in general be damp-free, rain-proof and away from petroleum products storage.

Permission may be granted by the engineer to erect suitable camps within the right of way free of charge, if such establishments do not cause obstructions to traffic, nuisance to works execution and adverse effect to the environment.

Written information must be given to and approval be taken from the Engineer regarding proper establishment and maintenance of such camps.

Failure in compliance with Engineer's instruction in respect of overall standard will lead to reduction or with holding of payment.

(4) Provision and Maintenance of Toilets

Provision of toilets for labour and employees shall be made to avoid public nuisance as well as pollution of water courses and air. The Contractor shall construct suitable septic tanks and/or soak pits along with room of pit-type latrines. Sufficient water must be provided and maintained in the toilets. Proper methods of sanitation and hygiene should be employed during the whole project duration.

(5) Provision of Potable Water

The Contractor shall supply potable water alongwith commencement of work to Contractor's staff and workperson both at camps and construction-sites. This arrangement shall be enforced to avoid proliferation and generation of various water borne-diseases.

The Contractor shall inform the Engineer regarding sources, installation and operation of supply of potable water within a week after the supply is commenced.

(6) Provision of First Aid/Medical Facilities

Provision of first aid/medical facilities shall be made alongwith commencement of work to provide quick medical service to injured/sick workperson, and employees. Services shall also include on-the way service and other arrangements required for taking them to the nearest hospital in case of emergency.

The scope of works shall include service of at least one part-time experienced health worker/health assistant with a minimum of once a week full time site visit as work assignment. The Contractor shall also supply and provide adequate medicines and facilities required for standard first aid.

The Contractor shall inform the Engineer regarding the medical facility within a week after its establishment and operation.

(7) Crushing Plants

Crushing plants shall be located away from the population centers, water intakes and should not disturb the sensitive echo system. Suitable dust control device shall be filled to be the crusher to control emission of dust from the plant.

(8) Hot Mix Plants and Batching Plants

Hot-mix plants an batching plants shall be located away from the population centers. The Contractor shall take every precaution to reduce levels of noise, vibration, dust and emission form his plants.

No bituminous material shall be discharged into drains. Nearby trees, vegetation and property shall be protected during spraying of bitumen.

(9) Hazardous Materials

The Contractor shall not store hazardous materials near water surfaces. The Contractor shall provide protective clothing or appliances when it is necessary to use some hazardous substances.

High concentration of airborne dust resulting in deposition and damage to crops and water resources shall be avoided. The Contractor shall take every precaution to control excessive noise resulting in disruption to wildlife and human population.

Only controlled explosives methods shall be applied and used in construction works.

(10) Reinstatetment of Environment

The Contractor shall arrange and execute works as well as related activities in such a way that environmental conditions are reinstated. He may be required to carry out filing, removal and disposal works along with plantation of grass and trees as directed by the Engineer at his own costs at identified locations to reinstate environment.

Written instruction/approval shall be given by/sought from the Engineer regarding reinstatement of environment both during and after completion of works and upto the end of Defects Liability Period.

(11) Measurement and Payment

No separate measurement and payment shall be made for the works described in this Clause.

110. PHOTOGRAPHS

(1) The Contractor shall supply negatives and unmounted positive colour prints of photographs, of such portions of the works in progress and completed, as may be directed by the Engineer. The negative of each photograph shall be

the property of the Employer and shall be delivered to the Engineer with prints. No prints from these negatives shall be supplied to anyone without the written permission of the Engineer.

The photographs shall be two categories:

(a) progress photographs (9 photographs, each of them shall have 4 prints and the negative supplied monthly)

(b) record photographs (9 photographs, each of them shall have 4 prints and the negative supplied monthly)

Both categories of photographs shall be properly referenced to the approval of the Engineer and on the back of each print shall be recorded the date of the photograph and the direction in which the camera was facing, and identifying description of the subject, and the reference.

The Contractor shall supply four prints of each photographs which shall be taken at locations and times determined by the Engineer.

Photographs taken for the record purposes as ordered by the Engineer shall be supplied with four prints, having on the reverse of one print the signature of the Contractor and the Engineer for the purpose of attestation. If required, the Contractor may at his own expense have an additional print similarly attested for his retention.

(2) Payment

Payment shall be made at the contract unit rate which shall be the full and the final payment to contractor as per Clause112.

111. SUPPLY OF VIDEO CASSETTES

(1) The work consists of taking video film of important activities of the work as directed by the Engineer during the currency of the contract and editing them to a video film of playing time between the 60 minutes and 180 minutes as directed by the Engineer. It shall contain narration of activities in English and/or Nepali by a competent narrator. The edition of the video film and the script shall be approved by the Engineer. The video cassettes shall be of acceptable quality and the film shall be capable of producing colour pictures.

(2) Measurement

The measurement for this item shall be by number of sets of edited master cassettes supplied each with four copies thereof.

(3) Payment

The contract unit rate shall include all expenses for making video films with the help of a professionally competent photographer, editing, narration and supplying the final edited master cassette alongwith four copies thereof.

112. NOTES ABOUT MEASUREMENT AND PAYMENT

(1) Measurement

Unless specified, all measurements shall be based on "Principals of Measurement (Int.) for works of constructions."

The tolerances specified in these Specifications are for evaluation of accuracies only based on which the work shall be accepted or rejected. However, the measurement of the work performed within the limits of tolerances shall be the measurement of actual work done in place, if their dimensions are less than what have been specified or instructed by the Engineer. If the actual work done in place is more than what has been specified or instructed by the Engineer, but within the limit of tolerance, the measurement shall be the measurement of the work what has been specified or instructed by the Engineer.

(2) Measurement

Unless specified in the Contract, the unit rates and/or prices for items as set out in the Bill of Quantities are the full and the final compensation to the Contractor for:

- Supply of all materials necessary to complete the item as per relevant specifications;
- Use of materials, labours, tools, equipment, machines and other resources as per need;
- All handling, packing charges and transportation;
- Site commissioning;
- Maintenance and making good;
- All duties and obligations as set out in the contract;
- General works such as setting out, clearance of site before setting out and after completion of works
- The preparation of detailed work programme
- Providing samples of various materials proposed to be used
- The detailed Design and Drawing of temporary works
- Testing of materials
- Any other details as required by the contract
- Cost of all operations like storing, erection, moving into final position, etc. necessary to complete and protect the work till handling over to the Employer;

- The cost for safeguarding the environment
- All incidental costs, not covered under above stated.

Where the Bill of Quantities does not include the items mentioned in Section 100, no separate payment shall be made for such works. The costs in connection with the execution of the works specified herein shall be considered to be included in the related items of other works specified in the Bill of Quantities or shall be considered to be incidental to the works specified. Items specified in this Section and included in the Bill of Quantities shall be paid at the contract unit rates as agreed and shown in the Bill of Quantities.

113. NATIONAL SPECIFICATIONS

Certain Specifications issued by various national or other widely recognized bodies are referred to in these Specifications. Such Specifications shall be defined and referred to as National Specifications.

The Contractor may propose that the materials and workmanship be defined in accordance with the requirements of other equivalent National Specifications and he may execute the works in accordance with such National Specifications as may be approved by the Engineer. A copy of the National Specification, together with its translation into the English language if the National Specification is in another language, shall be submitted to the Engineer along with the request for its adoption.

In referring to National Specifications, the following abbreviations are used:

NS	Nepal Bureau of Standards and Metrology
IS	Indian Standards
IRS	Indian Road Congress (i.e. Recommended Code of Practice by IRC
ASTM	American Society of Testing and Materials
BS	British Standards
BSCP	British Standard Code of Practice
AASHTO	American Association of State Highway and Transportation Officials
ISO	International Organisation for Standardisation
EN	European Norm
NFP	French Norm

Alongwith the commencement of the contract, the Contractor shall provide in his site office at least one complete set of all National Specifications referred to in these Specifications, if they are for the Sections applicable to the works. This set shall be made available for use by the Engineer.

114. EQUIVALENCY OF STANDARDS

Wherever reference is made in these Specifications to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work to be performed or tested, the provisions of latest current edition or revision of relevant standards and codes in effect shall apply. Other authoritative standards which ensure a substantially equal or higher performance than the specified standards and codes shall be accepted subject to the Engineer's prior review and approval. Differences between the standards specified and the proposed alternative standards shall be fully described by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event that the Engineer determines that such proposed deviations do not ensure substantially performance, the Contractor shall comply with the standards and codes specified. No payment shall be made for adoption of higher standards.

115. UNITS OF MEASUREMENT, ABBREVIATION AND TERMINOLOGY

(1) Units of Measurement

The Symbols for units of measurement are used in these Specifications as they are given below.

U	micron = $m*10^{-6}$
Mm	millimeter
M	metre
Km	kilometer
Sq.mm.or mm_	square kilometer
Sq.m.or m_	square meter
Sq.km.or km_	square kilometer
Ha	hectare
Cu.m.or m3	cubic metre
Lit or l	litre
Rad	radian
°C	degrees Celsius
kg	kilogram
g	gram = kg*10-3
mg	milligram = kg*10-6
mg/l	milligram per litre
t	tonne = kg*103
kg/m3	kilogram per cubic metre
t/m3	tonne pe cubic metre
N	Newton
N/m_	Newton per square metre
Lin.m	Linear metre
Max	Maximum
Min	Minimum

Symbols of other units, if not covered above, shall be as per SI system set out in ISO 31/1.

(2) Abbreviations

The following abbreviations are used in these Specifications.

ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ALD	Average Least Dimension
BA	Bitumen Affinity
BOQ	Bill of Quantities
CBR	Calilfornia Bearing Ratio
CR	Crushing Ratio
dia	Diameter
DOR	Department of Roads.
FI	Flakiness Index
Hr	Hour
LAA	Los Angeles Abrasion Value
LS	Linear Shrinkage
MC	Moisture Content
MDD	Maximum Dry Density
Min	Minute
No	Number (units), as in 6 no.
No	Number (order) as in No 6
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PI	Plasticity Index
PL	Plastic Limit
PM	Plasticity Modulus (PI * % passing 0.425 mm sieve)
POL	Petrol, Oil & Lubricant
ROW	Right of Way
SE	Sand Equivalent
sec	Second
SG	Specific Gravity
SI	International Standard Units of Measurements
SSS	Sodium Sulphate Soundness test, loss on 5 cycles
STV	Standard Tar Viscosity
TS	Tensile Strength
UC	Uniformity Coefficient
UCS	Unconfined Compressive Strength
VIM	Voids in Mix
w/c	Water cement ratio
wt	Weight
%	Percent

(3) Terminology

The term "the Specifications" shall be construed as the Standard Specification and the Special Specification all together.

(4) The Sections, Clauses and/or Sub-Clauses mentioned in these Specifications deem to apply those of these Specifications only, if otherwise not specified.

116. PROGRAMME

The Contractor shall provide all information needed for fulfillment of the programme and required in accordance with the Conditions of Contract including the sequence in which he intends to work including implementation of quality assurance plan. If the Contractor requests a change in the sequence and such change is approve by the Engineer, the Contractor shall have no claim as per the Conditions of Contract for delay arising from such revisions to the programme.

The programme for the construction and completion of the works shall be established using CPM/PERT techniques or equivalent. The programme shall be detailed enough to give, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of critical materials and equipment, fabrication of special products/equipments if any their installation and testing, and for all activities of the Engineer that are likely to affect the progress of work. The Contractor shall update all activities in accordance with the Conditions of Contract on the basis of the decision taken at the periodic site review meetings or as directed by the Engineer.

The programme shall also include the Contractor's general requirements for any road closures pursuant to Clause 102 to be agreed in principle with the Engineer. Such agreement shall not relieve the Contractor of his responsibility to obtain specific approval for each closure or series of closures.

Any proposal for night working shall also be stated in the programme.

SECTION 200 – SITE CLEARANCE

SECTION 200 – SITE CLEARANCE

201. CLEARING AND GRUBBING

(1) Scope

The Section covers the clearing and grubbing necessary for the construction of the works covered by the contract. Conservation of the top soil and flora is also covered under this Section.

(2) Description of Work

(a) Clearing

Clearing shall consist of the cutting, removing and disposal of all tree, bushes, shrubs, grass, weeds, other vegetation, anthrills, rubbish, fences, top organic soil not exceeding 150 mm in thickness and all other objectionable material, resulting from the clearing and grubbing. It shall also include the removal and disposal of structures that obtrude, encroach upon or otherwise obstruct the work.

The moving of a certain amount of soil or gravel material may be inherent to or unavoidable during the process of clearing and no extra payment shall be made for this. Clearing shall include the removal of all rocks and boulders of up to 0.15 m3 in size exposed or lying on the surface.

(b) Grubbing

In the roadway all trees upto 300 mm girth, stumps and roots shall be removed to a depth of not less than 900 mm below the finished road level and a minimum of 500 mm below the original ground level whichever is lower.

Except in borrow areas the cavities resulting from the grubbing shall be backfilled with approved material and compacted to a density not less than the density of the surrounding ground.

(c) Conservation of Top Soil

Where suitable topsoil exists within the limits of the area to be cleared and grubbed, the Contractor shall, if ordered by the Engineer, remove the topsoil together with any grass and other suitable vegetation. If not used immediately, the topsoil shall be transported and deposited in stockpiles for later use.

(d) Conservation of Flora

Where provided for in the contract, certain designated flora encountered in the road reserve and borrow areas shall be carefully protected by the Contractor. In his tendered rate for Site Clearance, he shall include for the careful removal and planting of the flora in a protected and fenced-off area and, on completion of the road, for the replanting of the flora in suitable positions in the road reserve in accordance with the Engineer's instructions.

(3) Execution of Work

(a) Areas to be Cleared and Grubbed

Stumps, embedded logs, roots and all other vegetation growth and accumulated rubbish of whatsoever nature and all other objectionable material shall be completely removed to a depth as specified in Sub-clause 201 (2) (a) and (b).

Normally the portions of the road reserve that fall within the limits of the road prism, as well as certain borrow areas shall be cleared and/or grubbed. Where the road reserve is to remain unfenced, the full width of the road reserve shall be cleared and/or grubbed except for such trees designated by the Engineer to be left standing and uninjured.

The Contractor shall mark the boundaries of the area for clearing and grubbing and seek the approval of the Engineer before commencement of the work. The Engineer shall designate in detail the exact areas to be cleared, and grubbed and the time at which it shall be done.

(b) Cutting of Trees

The Contractor shall take the necessary precautions to damage to structures and other private or public property. If necessary, trees shall be cut in sections from the top downwards. The branches of trees to be left standing shall be trimmed so as not to intrude into a space of 7m above the roadway.

Such individual trees as the Engineer may designate and mark in white paint shall be left standing and uninjured. In order to minimize damage to trees that are to be left standing, trees shall be felled towards the center of the areas being cleared, if so required by the Engineer.

Permission for cutting trees must be obtained from the competent authority who may require that trees be numbered, measured and marked in the presence of officials from that authority. Cutting of such trees shall then be carried out by the Contractor and the timber stored at designated locations within the Right of Way.

Felling and cutting of trees on the site and pilling them off the site shall conform to the requirements of the competent authority.

All tree trunks and branches in excess of 150 mm in diameter shall be cleaned off, secondary branches cut into suitable length and stacked at sites indicated by the Engineer. Such timber shall not be used by the Contractor for any purpose and shall remain the property of the Employer.

All timber except such timber as can be used and all brush, stumps, roots, rotten wood and other refuse from the clearing and grubbing operations shall be completely removed from within the Right of Way.

(c) Dealing with Anthills

Where anthills are encountered within the limits of the road prism, they shall be excavated to a depth of not less than 750 mm below the finished road level and the material carted to spoil. Cavities resulting from the clearance of anthill material shall be backfilled with approved material and compacted to a density not less than that of the surrounding ground.

Where directed by the Engineer, the area covered by anthills shall be treated, after excavation and before backfilling of cavities, with an approved ant control chemical. Payment for such treatment shall be made in the manner specified in the contract.

(d) Disposal of Material

Material obtained from clearing and grubbing shall be disposed off in borrow pits or other suitable places and be covered up with soil or gravel as directed by the Engineer. The burning of combustible material shall not, normally, be permitted and may only be done with the prior written approval of the Engineer.

Where fences have to be taken down, fencing wire shall be neatly wound into reels and all such wire, together with all fence posts and other serviceable material from structures, etc., shall be stacked at sites indicated by the Engineer.

(e) Reclearing of Vegetation

When portions of the road reserve, borrow or other areas have been cleared in accordance with the Specifications, but in the course of time, vegetation grows again during construction, the Engineer may, if he considers it necessary, order that the area be recleared.

Before the bottom layer of the embankment is made, the Contractor shall grub up and remove any vegetation that may in the meantime have grown on the surfaces previously cleared and grubbed.

Such reclearing of areas previously cleared include the removal and disposal of grass, shrubs and other vegetation in the same manner as for the first cleaning operation. No separate payment shall be made for reclearing of vegetation.

(4) Measurement

Clearing and grubbing executed as per this Specification shall be measured in square meter.

Cutting trees including removal of stumps and their roots of girth above 300 mm and backfilling to required compaction shall be measured in number according to the sizes given below:

(a) Above 300 mm to 600 mm
(b) Above 600 mm to 900 mm
(c) Above 900 mm to 1800 mm
(d) Above 1800 mm

For this purpose girth shall be measured at a height 1 meter ground.

Cutting of trees upto 300 mm girth including removal of stumps and roots and backfilling of holes with compaction shall not measured separately.

(5) Payment

Clearing and grubbing and cutting trees shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112. The contract unit rate for cutting of trees of girth above 300 mm shall also include handling, salvaging, piling and disposing off the cleared materials with all leads and lifts.

202. DISMANTLING CULVERTS, BRIDGES, OTHER STRUCTURES AND PAVEMENT

(1) Scope

This work shall consist of removing as hereinafter set forth existing culverts, bridges, pavements, buildings and other structure like guard-rails, kerbs, manholes, catch basins, inlets, walls, drains etc., which are in place but interfere with the new construction or are not suitable to remain in place, and salvaging and disposing off the resulting materials and back filling the resulting trenches and pits.

(2) General

(a) Only those structures designated by the Engineer, or shown on the Drawings, shall be demolished or removed.

(b) Dismantling and removal operations shall be carried out in such a way that the adjacent pavement, structures are left intact and in place. All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to start of new work.

(c) Existing culverts, bridges, buildings and other structures which are within the road and which are designated for removal, shall be removed upto the limits and extent specified on the Drawing or as indicated by the Engineer.

(d) Materials that are to be salvaged shall be carefully removed and stockpiled near the site at a location designated by the Engineer. Materials which are to be salvaged or used in the reconstructed work, have been damaged or destroyed as a result of the Contractor's operations, shall be repaired or replaced by the Contractor at his expense. Materials that are not to be salvaged and stockpiled, shall be removed and disposed off away from the site by the contractor at his own expenses. In general, piling, piers abutments and pedestals shall be removed to at least 300 mm below ground level measured at the face unless a different depth is designated or specified. Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of all adhering material before being embedded in new concrete.

(e) When pipe culverts, wooden culverts, gabion walls or other structures with a salvaged value are removed, care shall be exercised in their safe removal. The material involved shall be kept intact without damage. The Contractor shall be responsible for the satisfactory removal of such structures in an usable condition.

(f) Salvaged reinforced concrete pipes, corrugated steel pipes, wooden boxes or other structures shall be stored at places as directed by the Engineer or shown on the Drawing. Structures or portions thereof which are specified in the contract for reerection shall be stored in separate piles.

(g) Timber or lumber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed therefrom and shall be stored in neat piles in locations suitable for loading.

(h) All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

(i) All salvaged materials shall be the property of the Employer.

(j) All materials obtained from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed off.

(3) Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the materials shall be so removed as not to cause any damage to the serviceable materials to be salvaged. The part of the structure to be retained and other structures nearby shall be safeguarded against any damages.

Where existing culverts/bridges are to be otherwise incorporated in the new work, only such parts of the existing structure shall be removed as are necessary and directed by the Engineer to provide a proper connection to the new work. The connection edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. The structure shall be removed in a condition suitable for re-erection unless otherwise shown on the Drawing. All members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

(4) Dismantling Other Structures and Pavements

In removing pavements, kerbs, gutters, walls and structures like catchpits, outlets, etc., where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with face perpendicular to the surface of existing structure. Sufficient removal shall be made to provide connections with the new work as directed by the Engineer. All pavements, base courses in carriageway and shoulders, etc. designated for removal shall be broken to pieces whose volume shall not exceed 0.02 cubic meters and stockpiled at designated locations if the materials are to be used later or otherwise arrange for disposal.

(5) Back-filling

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

(6) Measurement

Prior to commencement of dismantling, the work of dismantling structures shall be measured in the units given below:

Type of Work	Unit
(i) Dismantling brick/stone masonry/ Concrete (plan and reinforced)	cu.m.
(ii) Dismantling gabion	cu.m.
(iii) Dismantling steel structures	tonne
(iv) Dismantling timber structures	cu.m.
(v) Dismantling pipes, guard rails, Kerbs and gutters	lin.m.
(vi) Utility services	lump sum
(vii) Pavement	cu.m.
(viii) Dismantling pipe culverts	no.
(ix) Dismantling pitching and rip raps	sq.m.

Associated works like disposal, stockpiling, marking and numbering, etc., shall not be measured separately.

(7) Payment

The various dismantling works shall be paid at their respective contract unit rates which shall be full and the final compensation to the Contractor as per Clause 112 and for the cost of all operations involved for completion of this item.

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SECTION 400 – FENCING

SECTION 400 – FENCING

401. SCOPE

This Section covers the erection of new fences along the boundaries of the road reserve and/or camp site as indicated on the Drawing or directed by the Engineer.

It shall also include the erection and later removal of temporary fences other than temporary fences for bypasses. Except for when the Engineer allows otherwise, new fences as well as temporary fences shall be erected before construction on a particular portion of the road where work is commenced with.

402. MATERIALS

(1) Posts, Stays, Standards and Droppers

Posts, stays, standards and droppers shall be of the type and size indicated on the Drawing. Concrete posts shall comply with the requirements of IS 4996 and the mild steel posts shall comply with the requirements of IS 226.

(2) Bolts for Stay

Bolts shall be galvanized steel bolts of the required length and diameter. The diameter shall not be less than 12 mm. All the necessary bolts, together with nuts and washers, shall be supplied with each post.

(3) Wire

(a) Barbed Wire

Barbed wire shall comply with the requirements of NS: 168/2045 and shall be of mild steel grade, double strand, unidirectional twist wire, each strand 2.50 mm diameter for use at any height above ground. The wire shall be either lightly galvanized or fully galvanized, as specified in the Bill of Quantities.

(b) Smooth Wire

Smooth wire shall comply with the requirements of N.S. 163/2045 and shall be of the type specified below:

- Straining wire shall be 4 mm diameter, lightly galvanized wire.
- Fencing wire shall be high tensile grade, 2.24 mm diameter wire, either lightly or heavily galvanized, as specified in the Bill of Quantities.
- Typing wire shall be 2.50 mm diameter, mild steel, lightly galvanized wire for tying fencing wire to standards and

droppers, and 1.6 mm diameter, mild steel, lightly galvanized wire for tying netting and mesh wire to fencing wire.

(4) Wire Netting

Wire netting shall be heavily galvanized mild steel wire with a minimum diameter of 1.8 mm and hexagonal mesh of 60 * 80 mm or as shown on the Drawing.

The width shall be as shown in the Drawing.

(5) Gates

Gates shall be complete in every respect, including hinges, washers, bolts and locking chain attached to the gate.

(6) Manufacturing Tolerances for Wire

Nowhere the actual diameter of the wire shall be less than the specified diameter by more than the following tolerances:

Specified diameter	**Tolerances**
Up to 1.5 mm	(+/-) 0.03 mm
Above 1.5 mm up to 2.5 mm	(+/-) 0.04 mm
Above 2.5 mm	(+/-) 0.05 mm

403. INSTALLATION OF POST AND STANDARDS

Straining posts shall be erected at all ends, corners and bends in the line of fences and at all junctions with other fences. Straining posts not be spaced further apart than shown on the Drawing. The height of posts above ground shall be such that the correct clearance between the lowest wire and the ground can be obtained.

Posts shall be accurately set in holes and where shown on the Drawing be provided with concrete bases to the dimensions shown on the Drawing.

Holes shall be dug to the full specified depth of the posts. Where due to the presence of rock the holes cannot be excavated by means of hand or pneumatic tools and the Contractor has to resort to the use of explosives, he shall be paid separately for the drilling and blasting operations required.

Corner, gate, end and straining posts shall be braced by means of stay or anchors, as shown on the Drawing or as directed by the Engineer. Pipe stays shall be bolted to the posts.

Standards shall be firmly planted into the ground at the spacing shown on the Drawing or as directed by the Engineer. The spacing of standards between any two straining posts shall be uniform and not greater than that shown on the Drawing. In rock or hard material standards shall be either driven or set in holes drilled into the rock. The size of drilled holes shall be such that a tight fit is obtained. Care shall be exercised when driving standards in order to prevent buckling or damaging them.

All posts and standards shall be accurately aligned and set to plumb. After posts and standards have been firmly set in accordance with the fore-going requirements, the fence wire shall be attached thereto at the spacing shown on the Drawing.

404. INSTALLATION OF WIRE

All fencing wire shall be wired to the sides of standards or posts in order to prevent the wires from being displaced and becoming loose. The wire shall be carefully stretched and hung without sag in true alignment. It shall not be stretched so tightly that it breaks or the end, corner, straining or gate posts are pulled up.

Each strand of fencing wire shall be securely fastened in the correct position to each standard with soft galvanized binding wire. The binding wire for each horizontal fence wire shall pass through a hole or notch in the standard to prevent slipping of the fence wire in a vertical direction, while the ends of the wire shall be wrapped at least four times around the fencing wire to prevent it from moving in a vertical direction.

At end, corner, straining and gate posts the fencing wire shall be securely wrapped twice around the posts and secured against slipping by tying the end tightly around the wire by means of at least six snug, tight twists.

Splices in the fencing wire shall be permitted if made in the following manner using a splice tool. The end of each wire at the splice shall be carried at least 75 mm past the splice tool and wrapped snugly around the other wire for not less than six complete turns, the two separate wire ends being turned in opposite directions. After the splice tool is removed the space left by it in the splice wire shall be closed by pulling the wire ends together. The umused ends of wire shall be cut close so as to leave a neat splice.

The gaps between gate posts and the adjacent straining posts shall be fenced off with short fencing wires or as shown on the Drawing.

Droppers shall be tied to each fence wire with soft binding wire in the required position as specified for standards, to prevent slipping in a vertical direction. The spacing of droppers between any two straining posts shall be uniform. Anchoring to structures shall be done as shown on the Drawing.

The completed fences shall be plumb, true to line with all posts, standards and stays firmly set. The height of the lower fencing wire above the ground at posts and standards shall not vary by more than 25 mm from their prescribed relative vertical positions.

405. INSTALLATIONOF GATE

(a) Gates shall be installed at he positions indicated in the Drawing. The gates shall be hung on gate fittings in accordance with the requirements shown on the Drawing. Gates shall be so erected that they swing in a horizontal plane at right angles to the gate posts, clear of the ground in all positions. At pedestrian and security fences the double swing gates shall not leave a gap of more than 5 mm between them when closed and single swing gates shall not leave a gap of more than 5 mm from the gate post when closed.

(b) The Contractor shall, on completion of each Section of fencing, remove all cut-offs and other loose wire or netting so as not to create a hazard to grazing animals or a nuisance to the owners of the ground.

406. MEASUREMENT

The fencing shall be measured in linear metres inclusive of all excavations, installation of posts and standards, barbed wires, painting if any, entry gates and other requirements necessary to complete the work as per this Specification.

407. PAYMENT

The fencing, measured as stated above, shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

SECTION 500 – QUALITY CONTROL

SECTION 500 – QUALITY CONTROL

501. SCOPE

This Section covers the Quality Control System and procedures, Quality Assurance Plan, programme of tests, trials, general procedures for acceptance as well as laboratory arrangements and related facilities which are required for the selection and control of the quality of materials and workmanship.

502. CONTRACTOR RESPONSIBLE FOR THE QUALITY OF THE WORKS

All materials incorporated and all workmanship performed shall be strictly in conformity with the requirements of the Specifications and the Contractor shall be responsible for the quality of the works in the entire construction within the contract.

The Contractor shall provide, use and maintain on the Site, throughout the period of execution of the contract, a laboratory with adequate laboratory equipment operated by competent staff for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship in accordance with these Specifications. The list of laboratory equipment to be procured and laboratory facilities to be provided shall be got approved from the Engineer. The Contractor shall assume that tests shall be required on all materials to be used in the works and on all finished works and on all finished works or part of works.

503. QUALITY CONTROL SYSTEM

The Quality Control System comprises the methods, procedures and organization for the Quality Control of the works. The Contractor shall implement the Quality Control System in the following sequence:

(1) Sequence

(a) Complaint testing for materials including laboratory trials,

(b) Complaint testing for methods and equipment prior to the commencement of the work,

(c) Control testing during construction,

(d) Acceptant testing on completed works or parts of the works.

The Contractor shall carry out all necessary tests and shall report to the Engineer the results of such tests before submitting materials and/or finished works or part of works to the Engineer for approval in accordance with this Specification. In certain circumstances, tests may be carried out at the place of manufacture as per the Conditions of Contracts.

For satisfying himself about the quality of the works, quality control tests shall be conducted by the Engineer himself or by any other agencies deemed fit by the Engineer. Additional tests may also be conducted where in the opinion of the Engineer such tests are needed.

Before commencement of the work, the Contractor shall demonstrate a trial run of all construction equipment for establishing their capability to achieve the laid down Specifications and tolerances to the satisfaction of the Engineer.

(2) The supply, testing and monitoring shall be in compliance with a Quality Assurance Plan, Clause 504 and the provisions in the contract.

504. QUALITY ASSURANCE PLAN

The Contractor shall submit to the Engineer for his approval, the Quality Assurance Plan (QAP) which shall be based on the detailed Programme of the Works as per Clause 116 of these Specifications.

The Quality Assurance Plan shall include the following:

(1) The Quality Control Schedule Comprising of:

(a) The recapitulative test schedule and testing programme detailing the list of tests for compliance, laboratory trials, site trials and trials Sections, construction control tests and their frequencies, tests for acceptance of the completed works with their dates.

(b) Recapitulative list of “critical” acceptance testing procedures, for equipment or parts of the works which corresponds to the tasks on the Critical Path according to the construction Programme.

(c) Estimate of the number of tests to be carried out, list and number of appropriate equipment to conduct them, list of tests to be conducted outside the site laboratory, if any, identification of the outside laboratory where proposed to carry out the test.

(d) List of staff assigned to the laboratory, their position and responsibilities in the quality control procedures, their qualification and experience, general description and detailed organization of the laboratory activities.

(2) The list of sources of materials and/or of manufactured articles, their main characteristics, their identification mode as provided by the supplier when required; the programme of supply and procurement of material and/or manufactured articles in accordance with the Programme pursuant to Clause 116.

(3) The list of tests and quality control procedures to be implemented by the Sub-contractors, if any, pointing out the "critical" acceptance testing procedures relating to the Sub-contracted works, which correspond to the tasks on the Critical Path included in the Sub-contracted works.

The Contractor shall implement the Quality Control in compliance with the approved QAP.

The Engineer's approval of the QAP shall not relieve the Contractor from his responsibility of the quality of the Works as per the Conditions of Contract and these Specifications nor shall the Engineer's approval of the QAP exempt the Contractor of any procedure to inform the engineer in writing or request for the Engineer's approval or reapproval as specified in the Conditions of Contract and/or in these Specifications.

The Contractor shall monitor and update the QAP on the basis of the decisions taken at the periodic review meetings or as directed by the Engineer and in accordance with the programme of the works as per Clause 116 and the Conditions of Contract.

505. TESTING PROCEDURES AND SETS OF TESTS

For ensuring the quality of the work, the materials and the workmanship shall be subjected to testing in accordance with procedures, sets of tests and frequencies are not restrictive. The Engineer shall direct for the tests to be carried out as frequently as deemed necessary that the materials and workmanship comply with their Specifications.

Sets of tests to be carried out on the materials and the workmanship as specified in these Specifications are recapitulated in Clause 510. Where no specific testing procedure is mentioned in the Specifications, the tests shall be carried out as per the prevalent accepted engineering practice or directions of the Engineer.

506. LABORATORY TRIALS TO CONFIRM COMPLIANCE WITH SPECIFICATIONS

(1) Filling and Pavement Materials

Laboratory trials shall be carried out by the Contractor on filling and pavement materials proposed to be used in the works in their natural state. The laboratory trials shall establish a relationship between their specified requirements of the end product and properties which can be determined in the field for construction control purposes.

Laboratory mixes and site trials for bituminous mixes shall be carried out in accordance with the requirements of the Sections 600.

The mixed materials, the composition of which meets the specified requirements and is accepted by the Engineer, shall then be used in the site trials carried out in accordance with Clause 507 to ensure that all specified requirements of the completed pavement courses can be achieved.

The Contractor shall submit the proposals for the site trails to the Engineer at least two weeks before he intends to use the mixed materials in the site trials in accordance with Clause 507.

(2) Concrete

Laboratory trials for concrete mixes as specified in Clause 2004 shall be carried out by the Contractor to demonstrate that the compostion of the mixes proposed for the concrete meets the requirements of the Specifications.

The compositions of concrete mixes which meet the specified requirements and are accepted by the Engineer shall be then used in the site trials carried out in accordance with Clause 507.

507. SITE TRIALS OR TRIAL SECTIONS

(1) Earthworks and Pavement Materials

Site trails for laying and compaction shall be carried out by the Contractor on all earthworks and pavement materials proposed for the works, using the same constructional plant and methods proposed by the Contractor for use in the works. The trials shall demonstrate the suitability of the method and equipment for laying and compacting the material to the specified density and confirm that other specific requirements of the completed earthwork or pavement work can be achieved.

Each trial area shall be at least 100 metres long and to the full construction width and shall be laid to the specified depth for the material. It may form a part of the works provided it complies with the required Specifications. Any areas, which do not comply with the Specifications shall be removed and new trial shall be made.

The Contractor shall allow in his programme for conducting such site trials and for carrying out the appropriate tests on them in accordance with the Quality Assurance Plan. The trials on each pavement layer shall be undertaken at least 21 days ahead of the commencement of the related work.

The Contractor shall compact each section of the trial over the range of compactive effort the Contractor is proposing. The data in respect of the following shall be recorded for each level of compactive effort at each site trial:

(a) The composition and grading of the material before the site trial.

(b) The composition and grading of the material including the lime or bitumen content.

(c) The moisture content at the time of compaction and the optimum moisture content for the specified compaction.

(d) The type, size, tyre pressures, frequency of vibration and the number of passes made by the compaction equipment.

(e) The maximum dry density or target density as appropriate measured on a sample before and at intervals through the site trials.

(f) The density achieved.

(g) The compacted thickness of the layer.

(h) Any other relevant information as directed by the Engineer.

At least, eight sets of tests shall be made by the Contractor on each 100 metres length of trial section for each level of compactive effort. If all eight sets of results over the range of compactive effort proposed by the Contractor meet the specified requirements for the material, the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements. If required, the QAP shall be updated or modified on the basis of these data.

If, during the execution of the works, the construction control tests indicate that the requirements for a material are not being consistently achieved, then work on that layer shall be stopped until the cause is investigated by the Contractor. Such investigation may include further laboratory and site trials on the materials to determine a revised set of data as stated above which when agreed, shall be the basis on which all subsequent material shall be provided and processed to achieve the specified requirements.

(2) Concrete

Site trials for concrete mixes as specified in Clause 2004 shall be carried out by the Contractor to demonstrate the suitability of his mixing equipment. During the site trials, compliance with the Specifications for weighing equipment, storage of ingredients, means of transport for concrete, placing, compaction and curing shall be checked by the Engineer.

During the site trial a full scale sequence including placing and compaction of concrete shall be carried out on a part of the works which will represent

particular difficulties due to the presence of reinforcement, obstructions or others.

The Contractor shall allow in his programme for conducting the site trials and for carrying out the appropriate tests, including the time required to obtain compressive strength test results at 28 days. The Contractor shall inform in writing the Engineer at least two weeks before the date he proposes to use the concrete mixes in the site trials with all relevant data including the trial programme, the results of the laboratory trial tests for the proposed concrete mixes and compliance tests results of all constituents i.e. cement, aggregates, water and admixtures, if any.

(3) Production of Materials and Crushing Plant

Full scale site trials corresponding to one day production shall be carried out by the Contractor on all type of materials to be processed using the crushing plant, related devices and methods to demonstrate the suitability of the equipment to provide materials of the characteristics and performances specified in these Specifications.

At each stage of the processing, materials shall be sampled, and the following characteristics shall be determined in the laboratory and recorded:

(a) the grading of the material

(b) characteristics of the fine fraction : Sand Equivalent (SE): Mica Content; and if SE<40, Plasticity Index.

(c) Characteristics of the coarse fraction : LAA, AIV, ACV, FI, Adhesivity test, Crushing Ratio.

At least three sets of tests shall be conducted by the Contractor at each stage of the production. If all the three sets of results over the full sequence of production proposed by the Contractor meet the specified requirements for the materials, the site trial shall be deemed successful.

(4) Other Works and Equipment

Site trials for Prestressed Concrete Works, Painting of Structural Steelwork etc. are detailed in the relevant Sections of these Specifications.

Approval of the Engineer to a set of data recorded in a site trial shall not relieve the Contractor of his responsibilities to comply with the requirements of these Specifications

508. CONTROL TESTING DURING CONSTRUCTION

(1) Earthworks and Pavement Materials, Backfill to Drainage and Other Structures

All earthworks, pavement layers, and backfill to drainage and other structures shall be subject to control testing (process control) including, if required, testing by the Engineer in accordance with the Conditions of Contract and Clause 503. The Contractor shall allow in his programme or sequence of operations for any disturbance or delays occasioned by such control and testing.

(2) Other Works and Equipment

Quality Control procedures are detailed in the relevant Sections of these Specifications.

509. ACCETPANCE TESTS FOR COMPLETED WORKS OR PARTS OF THE WORKS

(1) Earthworks and Pavement Materials, Backfill to Drainage and Other Structures

The Contractor shall request, in writing for the Engineer's approval for each layer of each section of earthwork, pavement construction and backfill to drainage and other structures. Such requests shall be made only when the Contractor is fully satisfied that the section of the works concerned is in the condition required by the relevant Specifications. Such request shall be accompanied by the tests results required by the Sub-clause 503 (1) (a), (b), (c) and the relevant Sections of these Specifications.

The Engineer shall thereupon, without undue delay, inspect the Section for any visible defects including, heaving material (visible during compaction or on proofrolling) segregation, and for the uniformity of the mixing and compaction. If the visual aspects are satisfactory the Engineer shall test the Section of the works submitted and inform the Contractor in writing of the results of the tests specifying acceptance or rejection of the Section or the layer concerned.

Work on a layer shall in no circumstances commence until the preceding layer has been approved and accepted by the Engineer in writing. The Contractor shall be fully responsible for protecting and maintaining the condition of the work which has been submitted for approval.

Should any layer be left unprotected for more than 24 hours subsequent to approval, the Contractor shall request for reapproval of the layer and the

layer shall again be subject to proofrolling, construction control testing, and tolerance checks in accordance with these Specifications.

Notwithstanding the Engineer's approval of a layer, the Contractor shall be responsible for making good any subsequent damage due to traffic, ingress of water or any other reason and should any damage occur the layer shall again be subject to proofrolling, construction control testing and tolerance checks in accordance with these Specifications.

(2) Other Works and Equipment

Acceptance tests for other works and equipment are detailed in the relevant Sections of these Specifications.

510. RECAPITULATIVE SCHEDULE OF TESTS

The tests to be carried out and their frequency for the quality control of the works are detailed in the relevant Sections of these Specifications.

The following Table 5.1 recapitulates the testing schedule for the main types of works.

Table 5.1: Testing Schedule

PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
PIPE DRAINS, PIPE CULVERTS AND CONCRETE CHANNELS	700		
MATERIALS FOR RE-FILLING THE TRENCHES	701	IDENTIFICATION : Gradation, Plasticity Index, CBR In-Situ Density (95% MDD)	As specified or required by the Engineer
PRODUCTION OF MATERIALS NATURAL AND CRUSHED MATERIALS	800	• Site Trials: • Other tests on materials	• Before starting production • According to the relevant component of the works
EARTHWORKS	900		
FILL MATERIAL		• Material Identification, MDD, OMC, CBR	• For each new source and in every 1500 m3 or part of it • For each new source and in every per 250 m3 or part of it
COMPACTION		• MC • Field Density	• One set per 500 m2 of each layer with a minimum 3 test per Section

PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
SUBGRADE UNTREATED SUBGRADES, CAPPING LAYERS MATERIALS COMPACTION	1000 1003 & 1004	• Material Identification, MC MDD, OMC, CBR • Field Density	• For each new material and not less than once per 3000 • Once per 250 m2 of each layer or part of it.
MECHANICAL STABILISATION IN-SITU MATERIAL STABILISER MIXED MATERIAL COMPACTION	1005	• Material Identification, MC MDD, OMC, CBR • Grading, ES (for sand) • MDD, OMC, CBR, MC • Field Density	• One test for each new material and one test per 3000 m2 of each layer or part of it. • One test for each new source and one test per 500 m3 of additive material or part of it. • One test for each new material and one test or part of it. • Once per 250 m2 of each layer or part of it.
LIME STABILISATION IN-SITU MATERIAL LIME MIXED MATERIAL COMPACTION	1006	• Material Identification, MC, OMC, CBR • Quality of Lime • MDD, OMC, CBR, MC • Field Density	• One test for each new material and one test per 3000 m2 of each layer or part of it. • For each consignment delivered at the site. • One test for each new material and one test per 400 m2 of each layer or part of it. • Once per 250 m2 of each layer of part of it.
SUBBASE, BASE, HARD SHOULDER AND GRAVEL WEARING COURSE MECHANICALLY STABLE MATERIALS FOR SUBBASE MATERIALS COMPACTION	1200 1201	• Material Identification, MC, Gradation, Plasticity index, • MDD, OMC • Field Density and moisture content	• Once per 200 m3 or part of it and change in source with a minimum of 2 tests per Section. • Once per 1000 m3 or part of it and change of source, with a minimum of 2 tests per Section. Once per 500 m2 of each layer with a minimum of 2 tests per Section.

PART OR COMPONENT OF THE WORKS	SECTION/ CLAUSE No	TESTS	FREQUENCY
GRADED CRUSHED STONE FOR BASE AND SUBBASE	1202		
MATERIALS		• Material Identification, MC, Gradation, Plasiticity Index, FI	• Once per 200 m3 or part of it and change in source with a minimum of 2 tests per Section
		• LAA, AIV, Crushing Ratio,	• Once per 200 m3 or part of it and every change of source
		• SSS, CBR	• Once per 500 m3 or part of it & every change of source,
COMPACTION		• MDD, OMC	• Once per 1000 m3 or part of it & every change of source, with a minimum of 2 tests per Section.
		• Field Density and moisture content	• Once per 500 m2 of each layer with a minimum of 2 tests per Section.
WATER BOUND MACADAM BASE AND SUBBASE	1203	• Material Identification, Gradation, Flakiness Index,	• Once per 200 m3 or part of it and change in source with a minimum of 2 tests per Section
MATERIALS		• LAA, AIV	• Once per 200 m3 or part of it and change in source.
COMPACTION		• Field Density and moisture content	• Once per 500 m2 of each layer with a minimum of 2 tests per Section.
GRAVEL WEARING COURSE			
MATERIALS	1205	• Material Identification, Gradation, Plasticity Index, CBR, LAA, AIV	• Once per 300 m3 or part of it and for each new source
COMPACTION		• MDD,OMC	• Once per 400 m3 or part of it and for each change in sources
		• Field Density and moisture content	• Once per 200 m2 of each layer with a minimum of 3 test s per Section.
BITUMINOUS SURFACE AND BASE COURSE	1300		
PRIME COAT – TACK COAT	1302		
MATERIALS		• Quality of Binder	• Certificates from suppliers. • One set of tests for each 50,000 litres of supply or part of it
CONSTRUCTION		• Binder temperature for application	• At regular close intervals
		• Rate of spread of binder	• 2 tests per run

SURFACE DRESSING MATERIAL	1303	• Material Identification, Gradation, FI • LAA, AIV,CR • Degradability test, SSS • Striping Value	• Once per 50 m3 or part of it and change in source • Once per 250 m3 or part of it and change in source • Once per 500 m3 or part of it and change in source • One set of 3 specimens for each source of supply. Then, when warranted, by change in the quality of aggregates.

PART OR COMPONENT OF THE WORKS	Section/ Clause No.	TESTS	FREQUENCY
SAND ASPHALT MATERIALS	1309	• Material Identification, Gradation, Sand Equivalent Quality of Filler	• Once per 100 m3 or part of it and change in source • Once per 500 m3 or part of it and change in source • Per 50 tonnes or part of it and change in source
		• Quality of Bitumen Penetration test	• Certificates from suppliers. • One set of tests for each 50,000 litres of supply or part of it • At close intervals as directed by Engineer.
		• Mixture Grading and Bitumen Content Marshall stability,	• Each 100tonnes of mix or part of it
CONSTRUCTION		• Control of temperature	• As required
EMULSION AGGREGATE MIX MATERIALS	1310	• Material Identification, Gradation LAA, SSS, SE Quality of Filler • Emulsion Water Content Sieve test • Mixture Grading and Bitumen Content Marshall stability, flow or Duriez test	• Once per 100 m3 or part of it and change in source • Once per 500 m3 or part of it and change in source • Per 50 tonnes or part of it and change in source • Certificates from suppliers. • One set of tests for each 20,000 litres of supply or part of it. • Each 100 tonnes of mix or part of it • Each 100 tonnes of mix or part of it
CONSTRUCTION		• Compaction	• Each 100 tonnes of mix or part of it • Each 100 tonnes of mix or part of it • Per 500 m2 or part of it
COLD ASPHALT MATERIALS	1311	• Material Identification, Gradation, LAA, ACV, SSS, SE Flakiness Index Quality of Filler	• Once per 100 m3 or part of it and change in source • Once per 500 m3 or part of it and change in source • Once per 100 m3 or part of it and change in source
CONSTRUCTION		• Emulsion Water Content Sieve test	• Per 50 tonnes or part of it and change in source • Certificates from suppliers. • One set of tests for each 20,000 litres of supply or part of it.

		• Mixture Grading and Bitumen Content Marshall stability, flow and voids • Compaction	• Each 100 tonnes of mix or part of it • Each 100 tonnes of mix or part of it • Each 100 tonnes of mix or part of it • Per 500 m2 or part of it

PART OR COMPONENT OF THE WORKS	Section/Clause No.	TESTS	FREQUENCY
CONCRETE MATERIALS	2000	• Cement : Acceptance tests: CONTROL TESTS: Chemical composition Physical properties • Aggregates : Acceptance tests: CONTROL TESTS: Grading Silt &clay content Organic Impurities Chloride content, sulphate content, Alkali reactivity Water, Admixtures	• Conservative samples for each supply and not less than every 200 t or part of it. • Testing in case of non compliance of the mixes or storage on site for longer than 1 month • Sub- clause 2003 (5) • Each delivery and every 100 t or part of it for fine aggregate and 250 t or part of it for coarse aggregate • As frequently as required. • Sub-clause 2003 (7) and (8)
		CONCRETE • LAB. TRIALS • SITE TRIALS • Control tests • Compressive strength	• Sub-clause 2401 (4) • Sub-clause 2401 (4) • Earth works: Every 6 m^3 of each class. When compliance is established: every 20 m^3 or part of it.
		REINFORCEMENT:	Clause 2014
MISCELLANEOUS STRUCTURES	2400		
GABIONS MATERIALS	2401	• Gabion wires: Tensile Strength, Mass, Uniformity and adhesion of Zinc coating • Specific gravity and water absorption of stones • Dismantling of gabion boxes for workmanship	• Sub-clause 2401 (4) • Sub-clause 2401 (4) • Every 50 m3 or part of it
CRIB WALLS	2402	• Gradation of backfill material	• Minimum one test for every 250 m3 or part of it and for each source of material
SUB-SURFACE DRAIN	2404	• Gradation Analysis	• One set of test for every 50 m3 and or part of it and for each change in source of material

BRICKWORKS FOR STRUCTURES MATERIALS MORTAR	 2502 2511	 • Quality of Bricks • Quality of cement and sand • Control tests Compressive strength of mortar	 • As required • Every 10 m^3 of brick work or part of it.
MASONRY FOR STRUCTURES MATERIALS MORTAR	2602 2610	• Quality of cement and sand • Control tests Compressive strength of mortar • Dismantling of masonry (1m_1m)	• As required. • Every 10 m^3 masonry of part of it. • Every 30 m^3 masonry of part of it.

511. LABORATORY

(1) The Laboratory shall be located on the site as described in the contract or shown on the Drawing. It may be established specifically for the contract with the approval of the Engineer.

(2) Setup

All laboratories to be provided under the contract shall be set up and shall be in fully operating condition not later than sixty days after the Engineer's order to commence the work.

No construction work shall be permitted until the laboratories have been accepted by the Engineer.

If the Contractor fails to provide the laboratories within the specified period, the Engineer shall make alternative arrangements as he considers necessary. These arrangements may include the use of rented accommodation, purchased caravans, portacabins and/or the contracting of laboratory services etc. The Contractor shall bear all the costs of such temporary arrangements made by the Engineer, including that of additional transport.

(3) Laboratory Equipment

All equipment necessary for testing of materials and workmanship shall be deemed to form part of the permanent works unless otherwise provide in the contract. It shall be delivered to the site in accordance with the schedule of requirements of such equipment described in the contract. However the non-inclusion of any item of such equipment in the schedule of requirements shall not relieve the Contractor of the responsibility to supply it if it is required for the proper control of the quality of the materials and/or workmanship, notably when identified in the list of appropriate equipment to be supplied in accordance with Clause 504 (1) (c). The equipment shall be delivered to the site not later than sixty days after the order to commence the works.

(4) Ownership

Unless otherwise stated in the contract the ownership of all laboratories and equipment shall revert to the Contractor.

(5) Attendance

The Contractor shall keep the Laboratories in a well maintained, clean and habitable condition.

The Contractor shall keep all laboratory equipment in good working condition throughout the period of the Contract at his own expense.

The Contractor shall provide all tools, consumable items for testing and all the assistance as may be required by the Engineer and his staff for measuring and checking the works.

(6) Measurement

(a) The laboratory which has been sent up and equipped as per requirement of these Specifications shall be measured for payment in number.

(b) Laboratory Equipment

The laboratory equipment provided as per the required list of these Specifications shall be measured for payment in one lot for each laboratory.

(c) Laboratory Staff

The laboratory staff assigned as per requirement confirming to the list provided in the contract shall be measured in man-month for each personnel. The man-month shall include the holidays and leaves as specified in the contract.

(7) Payment

(a) Laboratory

The laboratory as measured in number shall be paid as per the contract price on lumpsum basis. The contract price shall be the full and the final compensation to the Contractor for providing the laboratories premises; electricity supply; water supply, gas and heating, attendance etc. in accordance with the requirement of the Specifications.

(b) Laboratory Equipment

The laboratory equipment measured in a lot shall be paid as per contract price on lump sum basis. The contract price shall be the full and the final compensation to the Contractor for providing and maintaining all the equipment required for the proper control of the quality of the materials and/or workmanship in accordance with these Specifications. The price shall also include the cost for tests to be conducted outside the site laboratories.

(c) Laboratory Staff

The laboratory staff shall be paid at the contract unit rate for each personnel required and assigned to the laboratory, in accordance with their position and responsibilities. The duration of the personnel shall

be as required by the quality control and testing activities according to the general programme of testing. The remuneration rate shall cover salaries, including overtime remuneration if any, allowances, bonuses, social charges and overheads, travel, accommodation and miscellaneous and incidental expenses etc. and all costs incurred by the Contractor for the staff who will render their services in the laboratory on site for the duration as required

SECTION 600 – MATERIALS AND TESTING OF MATERIALS

SECTION 600 – MATERIALS AND TESTING OF MATERIALS

601. SCOPE

This section covers the general requirements relating to materials, the specific requirements for basis materials, the tests and methods of testing which are required for the section and quality control of materials.

602. QUALITY OF MATERIAL

The materials supplied and used in the works shall comply with the requirements of these Specifications. They shall be new, except as provided elsewhere in the contract or permitted by the Engineer in writing. The materials shall be manufactured, handled and used skillfully to ensure completed works to comply with the contract.

603. SOURCES OF MATERIALS

The use of any on kind or class of material from more than one source is prohibited, except by written permission of the Engineer. Such permission, if granted, shall set forth the conditions under which the change may be made. The sources or kinds of material shall not be changed without written permission of the Engineer. If the product of any source proves unacceptable, the Contractor shall make necessary arrangements for the supply of acceptable material. Any claims for compensation associated with such arrangements or changes shall not be considered, unless the source of the unacceptable material is designated in the contract as a source of material.

In the case of borrow pits, gravel, sand, binder, soil deposits and rock quarries, the "source of material designated in the contract" shall be construed to mean:

(1) any restricted area (within the pit or quarry) which is designated as the source of material; or
(2) the entire area of the pit or quarry, if no such restricted area is designated.

Movements of equipment within the "source" as above defined shall not be considered as a "change of source"

Selection and exploitation of material sources as well as use of the materials shall follow the DOR Environmental Guidelines (latest publication) and comply with order pertinent environmental specifications including those detailed in Section 100 & 800.

When any manufactured product, either new or used is to be furnished by the Employer, the location at which such material shall be delivered to the Contractor shall be designated in the contract. In such cases, the Contractor shall haul the materials from the designated delivery point to the point of use. The compensation for such hauling shall be included in the contract unit rate for placing the materials in the finished work.

604. INSPECTION AND ACCEPTANCE OF MATERIAL

Final inspection and acceptance of materials shall be made only at the site of the work. The Engineer reserves the right to sample, inspect, and test the materials throughout the duration of the works and to reject any materials which are found to be unsatisfactory.

A preliminary inspection of materials may be made at the source for the convenience and accommodation of the Contractor, but the presence of a representative of the Engineer shall not relieve the Contractor of the responsibility of furnishing materials complying with their Specification.

The representative of the Engineer shall have free entry at all times to those parts of any plant which concern production of the Materials ordered.

605. MATERIALS AND MANUFACTURED ARTICLES

(1) Order for Materials and Manufactured Articles

The Contractor shall, before placing any order for materials and manufactured articles for incorporation in the Works, submit to the Engineer the names of the firms from whom he propose to obtain such materials and manufactured articles, giving for each firm a description of the materials and manufactured articles to be supplied, their origin, the manufacturer's specification, quality, weight, strength and other relevant details. The Contractor shall submit the samples of such materials and manufactured articles when requested by the Engineer and when appropriate, manufacturer's certificates of recent test carried out on similar materials and manufactured articles shall also be submitted.

(2) Storage

All materials and manufactured articles shall be stored on site in a manner acceptable to the Engineer. The Contractor shall carefully protect all work, materials and manufactured articles from the weather and vermin.

(3) Test Certificates

When instructed by the Engineer, the Contractor shall submit to him all Test Certificates from the suppliers/manufacturers of the materials and/or manufactured articles to be used for the contract. Such certificates shall certify that the materials and/or manufactured articles concerned have been tested in accordance with the requirements of these Specifications. All Test results shall be enclosed along with such certificates. The Contractor shall provide adequate means of identifying the materials and/or manufactured articles delivered on the site with the corresponding certificates.

606. DEFECTIVE MATERIALS

All materials not conforming to the requirements of the contract shall be rejected whether in place or not. They shall be removed immediately from the site unless otherwise permitted by the Engineer. Even after rectification of the defects no rejected material shall be used in the work unless approved by the Engineer in writing. Upon failure of the Contractor to comply promptly with any order of the Engineer given under this Clause, the Engineer shall have authority to cause the removal and replacement of rejected material and to deduct the cost thereof from any monies due to the Contractor.

607. TRADE NAMES AND ALTERNATIVES

For convenience in designation in the contract, certain articles or material to be incorporated in the work may be designated under a trade name or the name of a manufacturer and his catalogue information. The use of an alternative article or material which is of equal or better quality and of the required characteristics for the purpose intended shall be permitted, subject to the following requirements:

(1) The proof as to the quality and suitability of alternatives shall be submitted by the Contractor. He shall also furnish all information necessary as required by the Engineer. The Engineer shall be the sole judge as to the quality and suitability of alternative articles or materials and his decision shall be the final and binding upon the Contractor

(2) Whenever the specifications permit the substitution of a similar or equivalent material or articles, no tests or action relating to the approval of such substitute material shall be made until the request for substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. Such request shall be made well in advance to permit approval without delaying the work.

608. FOREIGN MATERIALS

Materials which are manufactured, produced or fabricated outside Nepal shall be delivered at a point in Nepal as specified in the contract where they shall be retained for a sufficient time to permit inspection, sampling, and testing. The Contractor shall not be entitled to an extension of time for acts or events occurring outside Nepal and it shall be the Contractor's responsibility to deliver materials obtained from outside Nepal to the point of delivery in Nepal. The Contractor shall supply the facilities and arrange for testing required at his own cost. All testing by the Contractor shall be subject to witnessing by the Engineer.

The Contractor shall furnish to the Engineer a "Certificate of Compliance" with the specifications form the manufacturer, producer or fabricator of foreign material where required. In addition, certified mill test reports clearly identifiable to the lot of material shall be furnished where required in these Specifications or

otherwise requested by the Engineer. Where structural materials requiring mill test reports are obtained from foreign manufacturers, such materials shall be furnished only from those foreign manufacturer who have previously established, to the satisfaction of the Engineer, the sufficiency of their in-plant quality control, as deemed necessary by the Engineer or his representative, to give satisfactory assurance of their ability to furnish material uniformly and consistently in conformance with their Specifications. At the option of the Engineer, such sufficiency shall be established whether by submission of detailed written proof thereof or through in-plant inspection by the Engineer or his representative.

If the welding of steel for structural steel members or the casting and pre-stressing of pre-cast pre-stressed concrete members is to be performed outside of Nepal, the following requirements shall apply:

(1) Such fabrication shall be performed only within the plants and by fabricators who have previously established to the satisfaction of the Engineer, that they have the experience, knowledge, trained manpower, quality control, equipment and other facilities required to produce the quality and quantity of the work required. At the option of the Engineer, prequalification of plant and fabricator shall be established either by the submission of detailed written proof thereof or through in-plant inspection by the Engineer or his representative, or both.

(2) The Contractor shall make written application to the Engineer for approval for such foreign fabrication at the earliest possible time and in no case later than 60 calendar days in advance of the planned start of fabrication. The application shall list the specific units or portion of a work which shall be fabricated outside of Nepal.

(3) The Contractor shall advise the Engineer, in writing, at least 20 calendar days in advance of the actual start of any such foreign fabrication.

(4) All documents pertaining to the contract, including but not limited to, correspondence, tender documents, working drawings and data shall be written in the English/Nepali language and all numerical data shall use the metric system of units of measurement.

609. GENERAL : CLASSIFICATION OF MATERIAL

Classes of soil and classes of materials referred to in the relevant Section correspond to the General Classification of Soil and Materials for Road and Bridge Works in Nepal and are given in the Table 6.1, Table 6.2 and Table 6.3.

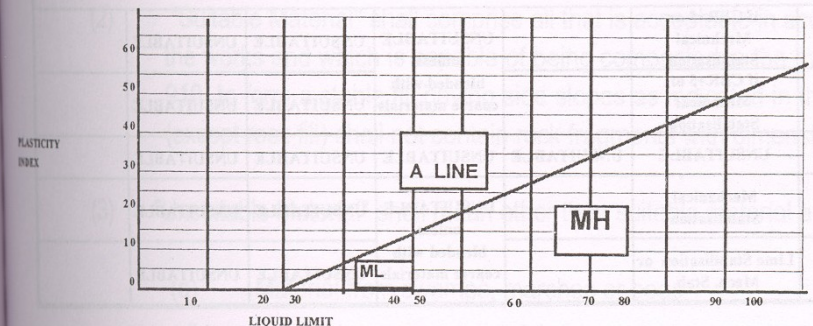
Table 6.1 shows the classification of rocks and soil and includes definitions, identifications criteria for stones and soils.

Table 6.2 shows conditions for rock and soil utilization as subgrade, capping layers and pavements

Table 6.3 shows Material Classification into Classes of Quality.

TABLE 6.1: General Classification of Natural Materials

	LITHOLOGIC TYPE	GENERAL TYPES	GROUP SYMBOL	TYPES IN NEPAL	COMMENTS ON CHARACTERISTICS
ROCKS	I. SEDIMENTARY ROCK & METAMORPHIC SEDIMENTARY ROCKS				EVOLUTIVE ROCKS TO BE MENTIONED
	CALCAREOUS ROCKS	METAMORPHIC LIMESTONE	R1	Limestone, Marble, Cipolins	Most tectonised limestone evolutting to Clay
		DOLOMITE	R2	Dolomite	Less evolutive than above.
	ARGILLOUS ROCKS	MARL, ARGILLYTES, PELITES	R3	Mudstone, Claystone	Most evolutive rocks producing Clay & High Plasticity Clay
	SILICEOUS ROCKS	QUARTZITE, SANDSTONE, PUDDING STONE, BROCKRAM	R4	Quartzitz, Sandstone	Fragile Sandstone desintegrating into sands
	II. MAGMATIC & METAMORPHIC ROCK				
	GRANITES, GABBRO, GNEISS METAMORPHIC SCHISTS. SHALES SLATES, AMPHIBOLITE, PHYLLITE...	FINE GRAINS ROCKS	R5	Granite, Aplite, Gneiss, Schists, Slates, Shales, Phyllite	Shales, lates, Phyllites, easily weathered into clay silts
		LARGE GRAINS ROCKS	R6	Pegmatite, Granite	Some Granite may be susceptible to desintegration
ROCK FALL, COARSE ALLUV. MATER.	SOILS CONTAINING LARGE BLOCKS OF ROCK MATERIAL OR BOULDERS WITHIN A MATRIX OF SOFT SOILS				
	BLOCKS SIZE > 0.3 m3		RF 1	Landslides	
	BLOCKS SIZE < 0.3 m3		RF 2	Arenaceous materials	
	GRADATION GENERAL CHARACTERISTICS	GRADATION QUALITY REQUIREMENTS	GROUP SYMBOL	TYPES IN NEPAL	
LOOSE MAT. & SOILS	I. GRAVEL & SAND				
	More than 50% of materials is larger than 0.075mm				
	GRAVEL More than 50% of materials is larger than 4.75mm				
	Less than 5% of materials is smaller than 0.075mm	Well graded gravel	GW	Alluvial Gravel	
		Poorly graded gravel	GP	Ancient Glacial terrasses, debris, screes	
	More than 12% of materials is smaller than 0.075mm	Silty Gravel	GM	Alluvial Gravel	If originating from evolutive rocks, may be sensitive to attrition
		Clayey gravel	GC	Ancient Glacial terrasses, debris, screes	
	SAND More than 50% of materials is smaller than 4.75mm				
	Less than 5% of materials is smaller than 0.075	Well graded sand	SW	Alluvial materials	
		Poorly graded sand	SP	Alluvial materials	
	More than 12% of materials is smaller than 0.075mm	Silty Sand	SM	Yellow silty sand (Terai)	
		Clayey Sand	SC	Ancient Glacial terrasses, debris, screes	
	II. FINE GRAINED SOILS				
	More than 50% of materials is smaller than 0.075mm				
	0	Atterberg Limits below A Line	ML	Ochre sandy silt, Laterite	
	Low Plasticity Clay	Atterberg Limits above A Line	CL	Laterites	
	Organic Silt & Clay	Organic test positive	OL		
	High Plasticity Silt	Atterberg Limits below A Line	MH		
	High Plasticity Clay	Atterberg Limits above A Line	CH	Grey Clay, Valley Clay (Kathmandu)	



A LINE GRAPH

Cu: Uniformity Coefficient
Cc: Coefficient of Curvature
D60 Grain Diameter at 60% passing
D30 Grain Diameter at 30% passing
D10 Grain Diameter at 10% passing

TABLE 6.2: Soils and Materials Identification and Utilisation

UTILISATION CONDITIONS Provided Compliance with the Specification and Special Specification

	GROUP SYMBOL	TYPES	IDENTIFICATION & CHARACTERISATION PROCEDURES	SUBGRADE	CAPPING LAYER	GRAVEL Wearing Course	SUBBASE	BASE	SURFACING
ROCKS	**SEDIMENTARY ROCK**								
	R1	LIMESTONE ROCKS	ACCORDING TO MATERIAL QUALITY CLASSES	SUITABLE provided compliance with the Specification for quality, grading & construction	SUITABLE provided compliance with the Specification	SUITABLE as Graded Crushed Stones (GCS)	SUITABLE as GCS Class D2	SUITABLE as GCS Class C1, B	SUITABLE as GCS Class A, B , (C1 seal coat)
	R2	DOLOMITE							
	R3	ARGILLOUS ROCKS			UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE
	R4	SILICEOUS ROCKS			SUITABLE d°	SUITABLE d°	SUITABLE d°	SUITABLE d°	SUITABLE d°
	MAGMATIC & METAMORPHIC ROCK								
	R5	FINE GRAINS ROCKS	ACCORDING TO MATERIAL QUALITY CLASSES			SUITABLE d° as GCS depending on Quality, Grading, (Specification)	SUITABLE as GCS Class D2	SUITABLE as GCS Class C1, B	SUITABLE AS GCS Class A,B
	R6	LARGE GRAINS ROCKS							
ROCK FALL COARSE ALLUV. MATER.	RF 1	BLOCKS SIZE > 0.3 m3	BLOCKS : According to material Quality Classes	* Embankments : Not to be placed within 600mm of the formation level. * Cuttings : to be removed from the subgrade (300mm deep)	SUITABLE d° after processing for Size reduction	SUITABLE d° as GSC after processing for Size reduction	After processing for size reduction SUITABLE as GCS Class D2	After processing for size reduction SUITABLE as GCS Class C1	After selection, processing for size reduction SUITABLE as GCS Class A,B,C1
	RF 2	BLOCKS SIZE < 0.3 m3	SOIL MATRIX : According to Soils & Gravels Testing Procedures.	Blocks > 0.05 m3 not to be placed within 450mm the formation level					
LOOSE MAT. & SOILS	**GRAVEL**								
	GW	Well graded gravel	According to Soils & Gravels Testing procedures	if CBR > 5,	if CBR > 15,	if CBR >20	if CBR >30	if CBR >80	SUITABLE for Bituminous Mixes according to Specification
	GP	Poorly graded gravel		if CBR > 5,	if CBR > 15,	if CBR >20	if CBR >30		
	GM	Silty Gravel	d°	if CBR > 5,		if CBR >20	if CBR >30	if CBR >80	
	GC	Clayey gravel	d°	if CBR > 5,		if CBR >20	if CBR >30 & PI <15	if CBR >80 & PI <15	SUITABLE d°
	SAND								
	SW	Well graded sand	d°	if CBR > 5,	if CBR > 15,	UNSUITABLE unless mixed with medium plasticity soils & coarse some coarse materials	if CBR >30	UNSUITABLE	Sand seal 0/10 Slurry Seal
	SP	Poorly graded sand	d°	if CBR > 5,	if CBR > 15,		if CBR >30	UNSUITABLE	
	SM	Silty Sand	d°	if CBR > 5 or Mech. Stab.			if CBR >30	UNSUITABLE	
	SC	Clayey Sand	d°	if CBR > 5,			if CBR >30 & PI = 5-12	UNSUITABLE	
	FINE GRAINED SOILS								
	ML	Low Plasticity Silt	d°	if CBR>5 or Mechnical Stabilisation		UNSUITABLE unless blended with coarse materials	UNSUITABLE	UNSUITABLE	
	CL	Low Plasticity Clay	d°	if CBR>5 or Mechnical Stabilisation			UNSUITABLE	UNSUITABLE	
	OL	Organic Silt & Clay	d°	. UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE	UNSUITABLE	
	MH	High Plasticity Silt	d°	Mechanical Stabilisation		UNSUITABLE unless blended with coarse materials	UNSUITABLE	UNSUITABLE	
	CH	High Plasticity Clay	d°	Lime Stabilisation or Mech. Stab.			UNSUITABLE	UNSUITABLE	

Table 6.3: Classes of Material Quality

MATERIAL CLASSES		LAA %	A/V ACV %	SSS Test	Degradability Test %	Flakiness Index %	Crushing Ratio %
A		<25	<20	<12	<5	<20	100
B		<30	<20	<12	<5	<25	100
C	C1	<35	<25	<12	<5	<25	80
	C2*	<30	<20	<12	<5	<25	-
D	D1	<40	<30	<12	<5	<30	60
	D2	<35	<20	<12	<5	<30	-
E	E1	>35 & <50	<25	<18	<10	-	-
	E2	>40 & <50	<30	<18	<10	-	-
	E3	>50	<30	<18	-	-	-

(1) : Criteria to be applied to crushed materials only.
* Classes for rounded materials only.

610. DEFINITION OF GENERAL TYPES OF MATERIALS

The following definitions shall apply to materials in this Section and other relevant Sections.

(1) "Topsoil" shall mean the top layer of soil that can support vegetation. It shall include all turf acceptable for trufing.

(2) "Suitable Material" shall comprise all that is acceptable in accordance with the contract for use in the works and which is capable of being compacted in the manner specified in Clause 909 and 910 to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except rock fill) shall not contain rock fragments with dimensions of more than 75 mm.

(3) "Unsuitable Material" shall mean other than suitable material and shall include:

(a) Material form swamps, marshes or bogs;
(b) Peat, logs, stumps, perishable material, organic clays;
(c) Material susceptible to spontaneous combustion;
(d) Material in a frozen condition;
(e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45.

Materials stated above in d), if otherwise suitable shall be classified suitable when unfrozen.

(4) "Rock fill" shall consist of hard material of suitable size for deposition and compaction as given in Clause 909 and also may comprise rock as defined in Clause 903 and broken stones.

(5) "Well Graded Granular Material" Consisting of gravel and/or sand shall conform to Clause 609.

(6) "Rock Fall", coarse alluvial material shall be loose soils such as moraines, debris, or alluvial material containing large blocks or large boulders, individual blocks or boulders of hard materials greater than $0.3m^3$ each in volume, shall be classified as hard material.

(7) "Hard Material" shall mean any material which conform to the requirements of Sub-clause 903 (4).

611. SIEVE

IS sieve shall be used for all tests. Based on IS-460 the standard sieves series shall be as follows:

125; 90; 75; 63; 50; 45; 40; 37.5; 31.5; 25; 22.4; 20; 19; 16; 12.5; 11.2; 10; 9.5; 8; 6.3; 5.6; 4.75; 4.00; 2.8; 2.36; 2; 1.7; 1.4; 1.18; 1; 0.85; 0.71; 0.6; 0.5; 0.425; 0.400; 0.300; 0.250; 0.212; 0.180; 0.150; 0.125; 0.090; 0.075 mm

612. SOIL AND GRAVELS

(1) Sampling and Samples

Sampling of soil and gravels shall be carried out as specified or as directed by the Engineer.

Sample shall be prepared for testing as indicated in IS 2720 part I, except that:

(a) The mass (in g) of a sample required for sieve analysis is about 400D, D being the maximum particle size (mm)

(b) Sample containing particles larger than 19mm size shall be prepared for compaction and CBR tests as described hereunder, provided the proportion in weight of such particles is less than 30%:

An adequate quantity of representative material shall be sieved over the 50 mm and 19mm sieve shall be weighed and replaced with an with an equal mass of material passing the 19 mm sieve and retained on the 4.75 mm sieve. The material for replacement shall be taken from the remaining portion of the main sample.

When preparing gravel samples, the aggregations of particles shall be broken with a wooden or rubber hammer or pestle. Care shall be taken that no individual particles are crushed in the operation.

(2) Standard Methods of Testing

Tests on soils and gravels shall be performed in accordance with the standard methods given in Table 6.4

Table 6.4: Tests Procedures Applicable to disturbed/Undistributed Samples of Soils and Gravels

Test	Test procedure	
Determination of:		
i) Moisture	IS 2720	Part 2 (Oven-drying method)
ii) Liquid Limit	IS 2720	Part 5 (Cone Penetrometer or by Casagrande apparatus)
iii) Plastic Limit	IS 2720	Part 5
iv) Plasticity Index	IS 2720	Part 5
v) Linear Shrinkage	IS 2720	Part 20
vi) Specific Gravity of Particles	IS 2720	Part 3
vii) Particles Size Distribution	IS 2720	Part 4
viii) Organic Matter content	IS 2720	Part 22
ix) Total Sulphate Content	IS 2720	Part 27
x) pH Value	IS 2720	Part 26 (Electrometric Method)
xi) Mica Content	-	Manual mineralogical counting
xii) Density - Moisture Content relationship (2.5 kg rammer)	IS 2720	Part 7
xiii) Density - Moisture Content relationship (4.9 kg rammer)	IS 2720	Part 8
xiv) California Bearing Ratio	IS 2720	Part 16
xv) Sand Equivalent	IS 2720	Part 37 (Mechanical Shaker or Manual Shaker Method)
xvi) Field Dry Density	IS 2720	Part 28/Part 29
xvii) Unconfined compression test	IS 2720	Part 10
xviii) Unconfined compression test	IS 2720	Part 15
xix) Direct shear test	IS 2720	Part 13
xx) Triaxial test	IS 2720	Part 11, 12
xxi) Hydrometer analysis	IS 2720	Part 4
xxii) Vane shear test	IS 2720	Part 30

It is further specified that:

(a) Wherever in the text of these Specifications and the Special Specification the term "x% of MDD (IS 2720 Part 27 and IS 2720 Part 28) is used it shall mean that a standard of compaction shall be achieved such that the dry density of the compacted material is x% of the maximum dry density determined from the respective tests mentioned in Table 6.4 Samples for the compaction tests shall be taken before compaction of the layers begins unless in the opinion of the Engineer the compactive effort proposed or applied by the Contractor is such that the

material characteristics have changed in which case the samples for the tests shall be taken after all compaction is complete.

(b) Compaction tests: when the material is susceptible to crushing during compaction, a separate and new sample shall be sued in the determination each point on the moisture/density curve.

(c) The dry density of material placed in the works shall be determined by the Sand Replacement Method unless the Engineer directs to use a nuclear method or other method. In the case of nuclear method, tests shall be done at least at the same frequency required when using the Sand Replacement Method, but at each nuclear densometer test location the average of three readings taken at positions rotated by 90o shall be used. A check/comparison test using the Sand Replacement Method shall be carried out at 10 test interval.

Initial calibration of the nuclear density testing equipment shall be done by carrying out at least fifty tests in parallel with the Sand Replacement Method for each different material encountered. The check tests shall be used to update the initial calibration of the nuclear density testing equipment.

613. STONE, AGGREGATE, SAND AND FILLERS

(1) Sampling and Preparation of Samples

Sampling shall be carried out as per ASTM-D75 and the samples shall be prepared in accordance with IS 2486 or according to sampling procedures specified for the Standard Methods of testing given in Table 6.5.

(2) Standard Method of Testing

Tests on stone, aggregate, sand and filler shall be performed in accordance with the standard procedures given in the Table 6.5.

Table 6.5: Test Procedures Applicable to Stone Aggregate and Fillers

Tests	Test Procedure	
Determination of:		
i) Particle Size Distribution (Gradation)	IS 2386	Part 1 Part 2
ii) Clay, Silt, Dust in Aggregates	IS 2386	Part 1
iii) Flakiness Index	IS 2386	Part 3
iv) Specific Gravity	IS 2386	Part 3

v) Moisture Content	IS 2386	Part 3
vi) Bulk Density, Voids & Bulking	IS 2386	Part 117
vii) Soluble Chloride Content	BS 812	
viii) Mica Content	Manual mineralogical Counting	
ix) Water Absorption	IS 2386	Part 3
x) Crushing Ratio	Manual counting & weighing	
xi) Los Angeles Abrasion	IS 2386	Part 4
xii) AIV-ACV	IS 2386	Part 4
xiii) Polished Stone Value	IS 2386	Part 4
xiv) Degradability Test	NFP 94 - 067	
xv) Sodium Sulphate Soundness	IS 2386	Part 5
xvi) Alkali Aggregate Reactivity Test	IS 2386	Part 7
xvii) Bitumen Adhesiveness (Vialit Test)	NFP-98-274-1	
xviii) Deleterious Substances	IS 2386	Part 2
xix) Sand Equivalent	IS 2720	Part 37
xx) Crushing Strength of Stone	IS 2386	Part 4

614. CEMENT

Ordinary and High Strength Portland Cement (OPC and HSPC), Portland Slag Cement (PSC), Portland Pozzolana Cement (PPC) shall be sampled according to IS 3535 and tested according to IS 4031.

Chemical and physical requirements for Ordinary Portland Cement, High Strength Portland Cement, Portland Slag Cement and Portland Prozzolana Cement shall be in accordance with IS 269, IS 8112, IS 12269, IS 455, IS 1489 respectively.

The requirements on their physical characteristics shall be as given in Table 6.6

Table 6.6: Requirement on the Physical Characteristics of Cement

S.N.	Physical Characteristics	OPC/PSC	HSPC	Test Procedure
i)	Finess, m2/kg: (by Blaine's Air Permeability method)	225	225	IS 4031 Part 2
ii)	Setting Time: (a) Minimum Initial Setting Time (minutes) (b) Maximum Final Setting Time	45	45	 IS 4031 Part 5

	(minutes)	600	600	
iii)	Soundness by Lechatelier Method, mm, maximum	10	10	IS 4031 Part 3
iv)	Compressive Strength: Minimum average Compressive Strength of three mortar cube (N/mm_) (a) 3 days (b) 7 days (c) 28 days	 16 22 33	 27 37 53	 IS 4031 Part 6

615. LIME

Limes shall be sampled and tested in accordance with BS 890 and shall comply with all requirements specified therein.

Lime for treatment of road materials shall be Hydrated Calcium Lime or Quicklime and, unless otherwise specified, shall comply with the requirements given in Table 6.7.

Table 6.7: Requirements of Lime for Treatment of Road Materials

S. N.	Characteristics	Hydrated lime	Quicklime
i)	Fineness Residue on 0.212 mm sieve – Maximum Residue on 0.775 mm sieve - Maximum	 1% 100%	 10% 50%
ii)	Chemical requirements Free lime content – Minimum Hydrated lime content - Maximum	 50% -	 60% 5%

616. LIME TREATED MATERIALS

(1) Sampling

Sampling and preparation of samples of lime treated material shall be carried out as specified or as instructed by the Engineer except that:

Samples containing particles larger than 19 mm shall be prepared for compaction and CBR tests as specified in Sub-Clause 612 (1) b). (The

fraction coarser than 19 mm shall be replaced by an equal weight of material passing through 19 mm sieve and retained on 4.75 sieve).

(2) Standard Methods of Testing

The tests on lime treated materials shall be performed in accordance with the Standard methods given in Tables 6.4 and 6.8.

Table 6.8: Additional Tests Procedures Applicable to Lime Treated Materials

Tests	Test Procedure
Determination of:	
(i) Unconfined Compressive Strength (UCS)	BS 1924 – Part 2
(ii) Effect of immersion on UCS	BS 1924 – Part 2
(iii)Lime Content	BS 1924 – Part 2

617. CONCRETE

Sampling and testing on concrete shall be carried out in accordance with the standard methods given in the Table 6.9

Table 6.9 Tests Procedures Applicable to Concrete

Tests	Test Procedure
Determination of:	
(i) Air contents of fresh concrete	BS 1881 - 106
(ii) Density of hardened concrete	BS 1881 – 114
(iii) Compressive strength of concrete cubes	BS 1881 - 116
(iv) Tensile splitting strength	BS 1881 – 117
(v) Flexural strength	BS 1881 - 118
(vi) Compressive strength of concrete cores	BS 1881 – 120
(vii) Water absorption	BS 1881 - 122
(viii) Mixing and sampling fresh concrete in laboratory	BS 1881 – 125
(ix) Normal curing of test specimens (20^{o} C method)	BS 1881 - 111
(x) Accelerated curing of test specimens	BS 1881 – 112
(xi) Marking test cubes from fresh concrete	BS 1881 - 108

Non destructive tests shall be carried out in accordance with the standard method and recommendations given in Table 6.10 as when required.

Table 6.10: Non-destructive Tests Applicable to Concrete

S.No.	Tests	References to Test Procedures

(i)	Method of hardened concrete for other than strength	BS 1881 – 5
(ii)	Guide to the use of non destructive methods of test for hardened concrete	BS 1881 – 201
(iii)	Recommendation for surface hardened testing by rebound hammer	BS 1881 – 202
(iv)	Recommendation for measurement of velocity of ultrasonic pulses in concrete	BS 1881 – 203
(v)	Recommendation on the use of electromagnetic cover meters	BS 1881 – 204
(vi)	Recommendation for the assessment of concrete strength by near to surface tests.	BS 1881 – 207

The test specimens shall be cured at a temperature of 27^{o} C $\pm$ 2^{o} C

Water to be used in concrete shall be tested as specified in BS 3148

The total chloride content, expressed as chloride ion, arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits, expressed as a percentage of the weight of cement in the mix:-

For prestressed concrete, steam cured concrete or concrete containing sulphate resisting or supersulphated cement : 0.1 percent

For any other reinforced concrete : 0.4 percent

The total sulphate content expressed as SO_3 of all the ingredients in a mix including cement water and admixtures shall not exceed 0.4 percent by weight of the aggregate or 4.0 percent of the weight of the cement in the mix, whichever is the lesser.

618. BITUMINOUS BINDERS

(1) Sampling and samples

Sampling of straight-run and cut-back bitumens shall be carried out in accordance with ASTMD 140.

Sampling of bitumen emulsion shall be carried out in accordance with BS 434, Part 1, except that where a delivery is made in drums or barrels, the number of samples shall be as indicated in AASTHO sampling method, T40 para.11.1.

(2) Standard Methods of Testing

(a) Straight-run Bitumen

Test on straight-run bitumen shall be carried out in accordance with the standard methods given in Table 6.11.

Table 6.11: Tests Procedure Applicable to Straight-run Bitumen

Tests	Test Procedure
Determination of:	
i) Penetration	ASTM D 5
ii) Softening point (Ring and Ball)	ASTM D 36
iii) Flash and fire points (Cleveland open Cup)	ASTM D 92
iv) Loss on heating	ASTM D 6/ D 1754
v) Ductility	ASTM D 113
vi) Water Content	ASTM D 146/ D 95
vii) Solubility in Trichloroethylene	ASTM D 2042
viii) Specific gravity	ASTM D 70
ix) Penetration of residue from loss on heating	ASTM D 5

(b) Cut Back Bitumen

Test on cut-back bitumen shall be carried out in accordance with the standard methods given in Table 6.12.

Table 6.12: Tests Procedure Applicable to cut-back Bitumen

Tests	Test Procedure
Determination of:	
i) Kinematic visosity	ASTM D 2170
ii) (a) Flash point (Tag open cup) (RC-MC)	ASTM D 3143
(b) Flash point (Cleveland open Cup) (SC)	ASTM D 92
iii) Penetration	ASTM D 5
iv) Specific gravity by hydrometer method	ASTM D 3142
v) Asphalt residue of 100 pen (SC)	ASTM D 243
vi) Water Content	ASTM D 95
vii) Distillation	ASTM D 402
viii) Penetration of residue from distillation	ASTM D 5
ix) Ductility of residue from distillation	ASTM D 113
x) Solubility of residue from distillation	ASTM D 2042

(c) Bitumen Emulsion

Test on bitumen emulsion shall be carried out in accordance with the standard methods given in Table 6.13.

Table 6.13: Tests Procedure Applicable to Bitumen Emulsion

Tests	Test Procedure

Determination of:	
i) Residue on 0.710 mm sieve	BS 434 Part I, Appendix C_1
ii) Residue on 0.150 mm sieve	BS 434 Part I, Appendix C_2
iii) Stability to mixing with coarse aggregate	BS 434 Part I, Appendix D_1
iv) Stability to mixing with cement	BS 434 Part I, Appendix D_2
v) Binder content	BS 434 Part I, Appendix E
vi) Engler iscosity	BS 434 Part I, Appendix F_1
vii) Redwovod II viscosity	BS 434 Part I, Appendix F_2
viii) Storage stability (short period)	BS 434 Part I, Appendix H_1
ix) Storage stability (long period)	BS 434 Part I, Appendix H_2
x) Particle charge	BS 434 Part I, Appendix J

(3) Requirements

(a) General

Before any bituminous binder is delivered to the site, the Contractor shall provide the Engineer with a certificate form the manufacturer that the material to be supplied complies in all respects with the relevant specifications.

Any bituminous binder delivered in leaking or deteriorated containers shall be rejected.

(b) Straight-run Bitumens

Straight-run bitumens shall comply with all the requirements give in Table 6.14

Table 6.14: Specification for Straight run Bitumen

S.N.	Specifications	Penetration Grade		
		60/70	80/100	180/200
i)	Penetration, at 25° C (100-5s), in 0.1 mm	60/70	80/100	180/200
ii)	Softening point (Ring and Ball), °C	44-54	41-51	33-42
iii)	Flash point (Cleveland open cup), °C (min)	250	225	200
iv)	Ductility at 25°C, cm (min)	100	100	100
v)	Loss on heating (5 h at 163°C) % (max)	0.5	0.5	0.5
vi)	Penetration of residue form loss on heating at 25°C (100-5s) % of initial pen (min)	80	80	80
vii)	Specific Gravity at 25°C	1.01-1.06	1.00-1.05	1.00-1.05
viii)	Water, % by weight (max)	0.2	0.2	0.2
ix)	Solubility in trichloroethylene, % by weight (min)	99.0	99.5	99.5

The number of tests and criteria for conformity shall be as per IS 73.

(c) Cut Back Bitumen

Slow curing, medium-curing and rapid curing cut-backs bitumen shall comply with all the requirements of ASTM Standard Specification D2026, D2027 and D2028 respectively and the number of tests and criteria for conformity shall be as per IS 217

(d) Bitumen

Bitumen emulsions shall comply with all the requirements of BS 434, Part 1.

619. BITUMINIOUS MIXTURES

(1) Sampling and Samples

Sampling of bituminous mixture shall be carried out in accordance with ASTM Method D 979.

(2) Standards Methods of Testing

Tests on bituminous mixture shall be carried out with the standard methods given in Table 6.15.

Table 6.15: Tests Procedure Applicable to Bituminous Mixtures

Tests	Test Procedure
Determination of:	
i) Moisture and volatile distillates	ASTM D 1461
ii) Quantitative extraction of bitumen	ASTM D 2172
iii) Specific gravity of compacted mixture	ASTM D 1188 & D 2726
iv) Recovery of bitumen from solution	ASTM D 1856
v) Coating and stripping	ASTM D 1664
vi) Degree of particle coating	ASTM D 2489
vii) Maximum specific gravity	ASTM D 2041
viii) Degree of pavement compaction	AASTO T 230
ix) Marshall stability	ASTM D 1559

620. REINFORCING STEEL

All reinforcement for use in the Works shall be tested for compliance as specified in Clause 2041 in a Laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. The sampling and frequency of testing shall be as set out in the NS 84-2042 and NS 191-2045. In addition to the testing requirements described above, the Contractor shall carry out additional testing as instructed by the Engineer.

621. TESTING OF WELDS

(1) The tests detailed in Clause 2206 shall be carried out by the methods described in BS 709. The following requirements shall also be met with.

(a) General

In any respect the test results of welded joints shall not be inferior to the British Standard test requirements for the parent material.

(b) Procedure Trials

i) Tensile and Bend Test

Should any one of the weld joint pieces selected for transverse tensile and transverse and longitudinal bend test fail to comply with the requirements applicable to the parent metal of the joint, 2 additional test pieces shall be taken from the joint material represented by the test. Both the test pieces shall comply with the requirements in order to qualify for the acceptance.

ii) Charpy V-notch Tests

Should the average impact value obtained form any set of 3 charpy V-notch tests on specimens fail to comply with the requirements, 3 additional test pieces from the same sample shall be tested. The average of the 6 test result shall comply with the requirements in order to qualify for acceptance.

iii) Revised Procedures

In the event of failure to meet the requirements, the Contractor shall carry out further trials, using revised procedures, and further tests to the satisfaction of the Engineer.

(c) Production Tests

(i) Tensile and Bend Tests

Should any one of the weld joint test pieces selected for transverse tensile and transverse bend tests fail to comply with the test requirements applicable to parent metal of the joint represented by the test, additional specimens shall be taken from the same production test

plates and the test shall be repeated. Should any of the additional tests fail to comply with the requirements, the joint shall be rejected.

(ii) Charpy V-notch Tests

Should the average impact value obtained from any set of 3 Charpy V-notch specimens selected fail to comply with the test requirements, 3 additional test pieces from the same production test plates shall be tested. Should the average of the 6 results fail to comply with the test requirements the joint shall be rejected.

(iii) Re-Welding and Re-Testing

In the event of failure to meet the test requirements the welded joint represented by the tests shall be completely cut out. The joint shall then be re-welded and the test repeated.

(iv) Non-destructive Testing

A method of non-destructive testing agreed with the Engineer shall be used for the examination of butt welds in tension members.

622. PAINT FOR STRUCTURAL STEEL WORK

The Contractor shall submit the proposal to the Engineer about the paint system to be used in the Works

The system shall comply with Sub-clause 2209 (9) and shall be defined at least by the following informations, supported by the paint manufacturer's data sheets:

- Type of system, composition of each component.
- Minimum thickness of each coat.
- Drying time at 10^{o}C within a range a relevant hygrometric conditions, including handling conditions, minimum and maximum time of overlap.
- Type of painting method and thinner content , (airless spray, brush, roller etc.)
- Thinner type
- Blending ratio.
- Maximum time limit of use, by 75% of relative humidity and for a relevant range of temperature and hygrometric conditions.
- Weather conditions constraint for painting and drying, including minimum and maximum ambient temperature and temperature of surfaces to be painted.

623. BRICKS

Bricks shall conform to NS-1-2035 with the exceptions specified in Sub-clause 2052 (1).

624. MORTAR

Mortar shall comply with Sub-clause 2052 (2).

625. REINFORCED CPMCRETE PIPES

Reinforced concrete pipes shall comply with the requirements of NS 80-2042/IS 485:1988.

626. HIGH DENSITY POLYTHENE PIPES

High density polythene pipes shall comply with the requirements of NS 40-2040.

627. GEOTEXTILES

Geotextiles used for sub-surface drains shall be made of polyethylene or polypropylene or polyster or similar fibres, either woven or nonwoven. Unless otherwise shown on the Drawing, the geotextile shall:

(a) sustain a load of not less than 10 kN/m at break and have a minimum failure strain of 10 percent when determined in accordance with BS: 6906 or shall have a grab tensile strength more than 0.4 kN/m and grab elongation corresponding to this limit in accordance with ASTM D 4632.

(b) have apparent opening size as shown on the Drawing. If no size is shown on the Drawing, then the apparent size shall be 0.1 mm.

(c) allow water to flow through it at right angles to its principal plane, in either direction at a rate of not less than 50 litres/sq.m/sec.under a constant head of 100 mm, determined in accordance with BS: 6909 (Part 3) or ASTM D4491, unless otherwise shown on the Drawing. The flow rate determined in the test shall be corrected to that applicable to a temperature of 15oC using data on variation in viscosity of water with temperature.

(d) have a minimum puncture resistance of 200 N when determined in accordance with ASTM D 4833.

(e) have a minimum tear resistance of 350 N when determined in accordance with ASTM D 4533. Geotextile used for drilled sub-surface drains shall be as specified in Clause 2405.

628. TIMBER FOR STRUCTURAL WORKS

Timber used for structural works shall comply with IS:883.

629. PAINT FOR ROAD MARKING

Paint for road marking shall comply with NS 408-2054. Paint used for other purposes shall be as specified in the respective sections of these Specifications.

630. MANHOLE COVERS AND FRAMES

Manhole covers and frames shall be of cast iron and shall comply with IS: 1726-1991. For manholes constructed in carriage way and shoulder, heavy duty circular covers and frames shall be used. In footpaths, medium duty circular covers shall be used. In other locations light duty covers and frames shall be used.

631. PRECAST CONCRETE CHANNELS

Precast concrest channels, kerbs, edging, quadrants and gutters shall comply with the requirements of IS: 5758 – 1984.

632. CAST IRON DRAINAGE GRATINGS

Cast gratings for drainage purpose shall comply with the requirements of IS: 5961 – 1970.

633. GABION

All wire used in the fabrication of gabions and wiring operations during construction shall comply with the requirements of NS: 169 – 2045. The wires shall be galvanized with heavy coating of zinc. The coating of zinc shall comply with NS: 163 – 2945 (Heavy Coated Wire) as given in Clause 2041.

634. MEASUREMENT AND PAYMENT

If otherwise not specified in the contract, no separate measurement and payment be made for sampling and testing of materials, trials and construction control/process control testing. It shall be deemed to have included in the rates of the relevant items for complying with the requirements of this Sections 600.

SECTION 700-PIPE DRAINS, PIPE CULVERTS AND CONCRETE CHANNELS

SECTION 700-PIPE DRAINS, PIPE CULVERTS AND CONCRETE CHANNELS

701. PIPE DRAINS AND PIPE CULVERTS

(1) Scope

This Clause covers the works for the construction of pipe drains and culverts with or without prefabricated reinforced cement concrete pipes and/or high density polythene pipes (HDP Pipes).

(2) Materials

(a) Reinforced Concrete Pipes

Reinforced concrete pipes shall comply with the requirements of NS 80/2042 or IS 458:1988.

(b) HDP Pipes

HDP pipes shall comply with the requirements of NS 40/2040.

(3) Excavation for pipe

The foundation bed for the pipe culverts/drains shall be excavated in accordance with Section 900 true to the lines and levels shown on the Drawing or to such other lines and depths as the Engineer may direct. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in existing embankments, taken down to the levels as shown on the Drawing. The additional width of the trench on either sides of the pipe shall be 150 mm or one-fourth of the diameter of the pipe whichever is more. Should the Contractor desire to use mechanical plant for excavating trenches or for laying pipes he shall submit his proposals for approval by the Engineer, but such approval shall not relieve the Contractor from his responsibilities in case of damage to pipes.

The pipe shall be placed where the ground for the foundation is reasonable firm. Where the bottom of the trench as excavated does not provide a suitably firm foundation for the culvert, due to soft, mucky or other unsuitable material being encountered, the unsuitable material shall be excavated to such depth, width and length as directed by the Engineer. The excavation shall then be backfilled with gravel or other approved granular material which shall be properly shaped and thoroughly compacted up to the specified level.

(4) Timbering Pits and Trenches

The sides of trenches shall, where required, be adequately timbered and supported to the satisfaction of the Engineer. All such excavations shall be

of sizes sufficient to enable the pipes and concrete to be laid accurately and the formwork withdrawn before refilling and ramming is carried out.

(5) Water in Excavation

Trenches shall be kept free form water until the pipes are installed and the joints have hardened. The Contractor shall, at his own expense, construct any sumps or temporary drains that the Engineer may consider necessary. The Contractor shall make good at his own expense, any damage caused by prolonged and excessive pumping, and shall take all precautions necessary for the safety of adjoining structures by shoring or otherwise, during the time the trenches are excavated or open.

(6) Laying and Jointing Pipes

Arrangement for handling lifting, loading, transporting, unloading, storage and lowering the pipes in bed shall be such that the pipes do not suffer any damage.

The pipes shall be laid true to line and level, commencing from the outfall. No pipes shall be laid until it has been approved by the Engineer. Pipes shall be laid such that each one is in contact with the bed throughout the length of barrel. The pipes shall be laid closely together against each other so as to obtain tight joints.

Where two or more pipes are be laid adjacent to each other, they shall be separated by a distance equal to half the diameter of the pipe subject to a minimum of 450 mm.

Concrete pipe culverts shall be laid on granular bedding or concrete bedding or as shown on the Drawing.

The concrete pipes shall be jointed either by collar joint or flush joint. In case of collar joint, the collar shall be of reinforced cement concrete 150 to 200 mm wide according to the diameter of the pipe and having the same structural strength as the pipes to be jointed. Caulking space shall be between 13 to 19 mm according to the diameter of the pipe as specified by NS 80/2042 or IS: 458:1988. caulking material shall be slightly wet mix of cement and sand in the ratio of 1: 2 rammed with caulking irons. Before caulking, the collar shall be placed such that its centre coincides with the joint and an even annular space is left between the collar and the pipe. In case of flush joint, the ends of the pipes shall be spaced to from a self centering joint with a joining space of 13 mm side. The jointing space shall be filled with cement sand mortar in the ratio of 1:2 Care shall be taken to fill all voids and to see that any excess of cement mortar is neatly cleaned off while each joint is being made and any earth, cement or other material thoroughly cleaned out of the pipes. All joints shall be made with care so that the interior surface is smooth and consistent with the interior surface of the pipes. After finishing, the joint shall be kept covered and damped for at

least four days. A properly fitted plug shall be well secured at the end of each pipes already laid and shall be removed only when next pipe is being laid or on completion of the culvert or drain. The trench shall be kept free from water until the joint are thoroughly set.

Jointing of HDP pipes shall be done by heating as prescribed by the manufacturer.

(7) Cement Mortar for Jointing

Cement mortar for jointing pipes shall consist of one part by weight of Portland cement to two parts by weight of sand. Sand shall comply with Sub-clause 2502 (2). The materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only and when required, and any mortar which has begun to set or which has been mixed for a period of more than the initial setting time shall be rejected.

(8) Pipe to be left Clean on Completion

On completion, all pipe lines, drains etc., shall be flushed from end to end with water and left clean and free from obstructions.

(9) Pipes Bedding and Encasing

Pipes shall be laid on granular or concrete bedding or as shown on the Drawing.

(a) Granular Bedding

The pipes shall be laid on a layer of fine granular material, 100 mm thick, after the bottom of excavation has been shaped to conform to the lower part of the pipe as shown on the Drawing. The bedding material shall be well graded granular material passing 5.6 mm sieve and suitable compacted.

(b) Concrete Bedding

Where indicated on the Drawing, the pipes shall be laid on grade M 10/40 concrete confirming to Section 2000 so that the bottom of the pipe rests on concrete of the specified thickness. The thickness of the concrete below the pipe and the height to which it extends upwards shall be as indicated on the Drawing.

(c) Concrete Encasing

Where shown on the Drawing, pipes shall be fully encased in concrete as shown on the Drawing. The grade of the concrete shall be as shown on the Drawing. In carrying out this work the Contractor shall take care to

pack the concrete under and around the pipes to ensure even bedding and solidity in the concrete; in no instance shall the concrete be thrown directly on the pipes. The concrete shall be placed in such a way that all spaces around the pipe are completely filled with concrete. Concrete casing shall be cast in one continuous operation until completed. The upper surface of the concrete shall be struck off with a wooden screed and neatly finished off.

(10) Joining New Work to Old Work

Where partial demolition is required for extension to the existing structures, the contact face shall be cut to predetermined lines and levels. The loose and fragmented material shall be removed and projecting steel cleaned and bent as directed by the Engineer. Where no partial demolition but only extension is required, the contact area shall be roughened and cleaned of all dirt and loose particles.

(11) Refilling Trenches

Backfill for pipes and minor drainage structure shall be obtained form the material excavated in forming the excavation. In the event of there being insufficient excavated material or the culvert is laid close to or above existing ground level then selected backfill shall be obtained from borrow pits. All backfill whether from excavated material or borrow pits shall be suitable material as defined in Clause 902 and shall have a CBR of at least 5% measured after 4 days soak on laboratory mix compacted to 93% MDD (Heavy Compaction), plasticity Index of less than 35%, maximum particle size of 40 mm and shall be compacted to a dry density of 93% MDD (Heavy Compaction)

For pipe culvert which have been placed and where no concrete haunch or surround is called for, selected fill of suitable material available form the excavation shall be place in layers not exceeding 150 mm of loose thickness. The material shall be uniformly mixed with water or dried out such that the moisture content at the time of compaction is between 95% and 100% of the Optimum Moisture Content. Then it shall be compacted thoroughly. Similar selected material shall then be laid in layers, not exceeding 150 mm of loose thickness, mixed, dried or watered as necessary and carefully compacted, and brought up uniformly on both sides of the pipe up to a height of not less than 300 mm over the crown. The remainder of the trench shall then be backfilled with suitable materials, placed in layers not exceeding 150 mm of loose thickness, mixed, watered or dried as necessary and carefully compacted. All backfilling material except the top 300 mm below formation level shall be compacted to a minimum dry density of 93% of MDD (Heavy Compaction). The top 300 mm below formation level shall be placed in layers not exceeding 150 mm of loose thickness, mixed, watered or dried as necessary and carefully compacted to at least 95% of MDD (Heavy Compaction).

For pipe culverts which have been constructed close to, above or where the culverts protrudes above the existing ground the backfilling under the flanks and alongside and over the culverts shall be placed and compacted in layers not exceeding 150 mm to a density of at least the density required for the material in adjoining layers of fill. All existing ground under this backfill shall be compacted to 93% MDD (Heavy Compaction) to a depth of 150 mm.

Backfilling shall be carried out simultaneously and equally on both sides of the culvert to avoid unequal lateral forces. In all cases there shall be cover of at least 600 mm over the crown of the culvert before construction equipment is driven over it unless protective measures approved by the Engineer have been provided.

(12) Inlet and Outlet Structures and Catch pits

Catch pits, headwalls, wing walls, aprons and other ancillary works shall be constructed in accordance with the details shown on the Drawing. Masonry for these works shall conform to Section 2500 or 2600 as applicable. Concrete shall conform to Section 2000 and aprons shall conform to Section 2400.

(13) Opening to Traffic

No traffic shall be allowed to cross the pipeline unless the height of the filling is not than 600 mm above the top of the pipe line or is as shown on the Drawing.

(14) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificate for each lot of pipes supplied. The test result shall meet the requirements of the Specifications.

Backfilling/Refilling shall be tested in accordance with Section 900 and all the test result shall meet the criteria specified. Compaction shall be tested in each layer of backfill, gradation of granular bedding shall be tested at least once a day and the test results shall meet the specified criteria.

The pipe drains/culverts shall be constructed to the true lines and levels indicated on the Drawing or instructed by the Engineer.

(15) Measurement

Pipes shall be measured along their centre between the inlet and outlet ends in linear meters of individual pipe element of each sizes, completed and accepted in place. Collar shall not be measured for payment. Excavation, bedding, concrete for encasing and backfilling works shall be measured separately in cubic. Ancillary works such as head walls, wing walls, etc.,

shall be measured as provided for in the respective Sections of these Specifications.

(16) Payment

Pipes, measured as provided above, shall be paid for at the contract unit rates per linear meter of each particular size which shall be the full and the final compensation to the Contractor as per Clause 112.

Cost for cement jointing shall deemed to be included in the contract unit rate of pipe.

Ancillary works such as excavation, backfilling, granular bedding and/or concrete for bedding/encasing and masonry shall be paid for separately, as provided under respective Clause of these Specifications.

702. CONCRETE CHANNELLING

(1) Scope

This Clause covers the works for the construction of concrete channeling for drainage.

(2) Material

Concrete channels may be pre-cast units or may cast in-situ. All concrete works and reinforcement shall be carried out in accordance with the requirements of Section 2000.

The material on which concrete is to be bedded shall be granular bedding as provided in Clause 701.

(3) Construction

(a) Excavation of Bedding

Trenches for channels shall be excavated to the required depth as shown on the Drawing. The bottom and side of the trench shall be neatly trimmed. All loose materials shall be thoroughly compacted. The bedding material shall then be laid on the bottom of the trench and it shall be thoroughly compacted and accurately shaped to the required line and level. No concrete shall be placed on un-compacted or disturbed material.

(b) Precast Concrete Channeling

Precast concrete channeling shall be laid with close joins with 1:2 cement sand mortar at the ends. The joints shall not exceed 10 mm in

thickness and shall be neatly pointed with a pointing trowel. Guide lines and straight edges shall be used to ensure that the exposed faces and edgings are set to true lines and levels.

Care shall be taken to protect all precast units against chipping or breakage during handling and laying. Broken or chipped Sections shall not be used and shall be replaced with undamaged units.

(c) Cast in-situ Channels

Channels shall be cast in alternative Sections. The length of Sections shall be uniform throughout and shall be equal to 2 m, except where shorter Sections are necessary for closures or where otherwise shown on the Drawing.

Forms shall be accurately set to line, levels and elevation and shall be firmly held in position during the placing of the concrete. Stops at the ends of Sections shall be placed accurately so as to ensure that the joints are truly perpendicular to the surface of the concrete and right angles to the edge of the road. After concrete has been placed in the forms, it shall be tamped and spaded until the exposed surfaces are entirely covered with mortar. Exposed faces shall then be finished to smooth and even surfaces.

The forms of exposed concrete surfaces shall be removed after 24 hours after the concrete has been placed. Minor defects shall be repaired with a 1:2 cement sand mortar. Plastering shall not be permitted on exposed faces and all rejected portions shall be removed and replaced at the Contractor's expense. Exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or wooden block and rubbing the surfaces until they are smooth. When the concrete has smoothed by using water, it shall be rubbed with a thin paste of 1:1 cement sand mortar until a uniform colour is obtained. When completed the Sections shall be cured in accordance with the requirements of Section 2000.

After the concrete in alternate Sections has been set, the intermediate Sections shall be cast and finished in accordance with all the requirements specified above. The exposed end surfaces of the alternate Sections cast first shall be painted with a coat of approved bituminous emulsion containing 60% of net bitumen by mass, and the emulsion shall be allowed to set and dry before the intermediate Sections are cast.

Guide lines and straight edges shall be used to ensure that the exposed faces are formed to the true line, level and elevation.

(4) Tests and Standard of Acceptance

All concrete works shall be tested in accordance with Section 2000 and the test results shall meet the specified criteria.

The concrete channeling works shall be constructed to the true lines and levels shown on the Drawing or instructed by the Engineer.

(5) Measurement

Concrete channeling shall be measured in linear meter. Formworks and reinforcement shall not be measured separately. Excavation and bedding shall be measured as provided under respective Sections of these Specifications.

(6) Payment

Concrete channeling shall be paid as per the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112. Excavation and bedding shall be paid as provided under respective Sections of these Specifications.

703. COMPLETION OF DRAINAGE WORKS

All culverts and/or other drainage works shall be completed well in advance of the construction of the base course, hard shoulders and/or surfacing of the carriageway.

SECTION 800 – QUARRIES, BORROW PITS, STOCKPILE AND SPOIL AREAS

SECTION 800 – QUARRIES, BORROW PITS, STOCKPILE AND SPOIL AREAS

801. GENERAL

Unless otherwise stated in the contact, it is the responsibility of the Contractor to select the sources of aggregates for concrete, stone for base, sub base, bituminous mix base binder course and wearing course, chipping for surface, rock fill for swamps etc. and the sources of natural/suitable materials, such as fill material, for the construction of embankments, gravel for sub base, base, surfacing and shoulder. Such sources shall be designated as rock quarries, quarries, alluvial deposits and borrow and are defined in Clause 802. Certain rock quarries, quarries, alluvial deposits, borrow pits may have or have been identified prior to the commencement of the contract and the Engineer shall instruct the Contractor as to which of these shall be utilized for the extraction as natural or suitable materials to be used in the works.

Provisions are included in subsequent clause of this Specification for additional rock quarries, quarries, alluvial deposits borrow pits to be identified and located by the Contractor during the contract. Stockpile and spoil shall be located by the Contractor subject to the approval the Engineer.

802. DEFINITIONS

(1) Rock Quarry

A rock quarry is an open surface working in massive rock form which stone is removed by drilling and blasting for use in the works.

(2) Quarry

A quarry is an open surface working form which stone or aggregate for sub base, base and surfacing are extracted for use in the works.

(3) Alluvial Deposit

An alluvial deposit is a site where gravel and aggregate of alluvial origin are extracted for use in the works.

(4) Borrow Pit

A borrow pit is a site from which loose material, other than stone, is removed for use in the works.

(5) Stockpile Area

A stockpile area is an area where material such as topsoil, fill material, gravel or aggregate is stockpiled prior to use in the works.

(6) Spoil Area

A spoil area is a site upon which surplus or unsuitable materials arising out of works are dumped within or beyond the road reserve as indicated on the Drawing or directed by the Engineer.

803. LOCATING MATERIAL SOURCES

(1) The Contractor shall be responsible for locating all material sources and for the acquisition or renting of all land required for rock quarries, quarries, alluvial deposit, borrow pits, spoil and stockpile areas and for access thereto in accordance with the Conditions of Contract.

The location and size of rock quarries, quarries, alluvial deposit borrow pits, spoil and stockpile areas proposed by the Contractor shall be subject to the approval of the Engineer.

The Engineer shall withhold his approval, if in his opinion the rock quarry, quarry, alluvial deposit, borrow pit, spoil and stockpile area, or access into them.

(a) will have a detrimental effect on the environment;
(b) would be very difficult to acquire;
(c) is in or near an urban centre;
(d) will require an access road which is excessively long;
(e) has excessively thick layers of overburden;
(f) covers too large an area;
(g) would constitute a danger to the public;
(h) is an excessive distance from the location where the material is to be used or removed from; or
(i) a source of suitable material is closer.

(2) The Contractor shall submit for the Engineer's approval full information regarding the proposed location of the material source not later than 30 days after issue the order to commence the works of all rock quarries, quarries, alluvial deposits, borrow pits, spoil and stockpile areas that the Contractor will require for the whole the works.

The Contractor's written notice shall include the following for each rock quarry, quarry, alluvial deposit, borrow pit, spoil and stockpile areas:

(a) A plan at 1:500 scale in ink on a stable transparent material giving details of:

i) plot boundaries;
ii) owners names and addresses, and if appropriate identification numbers;

iii) the District, Location, Registration Section and Number for each plot;
iv) local details such as building, fences, types and areas of cultivation and services, all agreed with the Land Owners; and
v) areas to be used for working areas, stockpile areas, safety blasting zones etc;

(b) Cadastral maps covering the areas to be acquired when available.

(c) Detail of the proposed access road route.

(d) Technical supporting information relevant to rock quarries, quarries, alluvial deposits, borrows pits, including:

i) Summary of geophysical surveys (electric, and/or seismic), geotechnical survey, indicating for alluvial deposit the thickness of layers, thickness of overburden, lenticular beds depth and configuration of the bedrock, etc., and in addition for rock quarries, the discontinuity families, the intervals between discontinuities, thickness and nature of the infilling, the Weathering Index.

ii) Laboratory results including petrographic identification, and for alluvial deposit material, grading, tests on the fine fraction (PI, SE, Methylene Blue test, Mica content, Organic matters), tests on the coarse fraction (LAA, AIV, ACV, Micro Deval, FI, Adhesivity test), CBR test, or for quarry material, LAA, AIV, ACV, Micro Deval, Adhesivity test, Specific Gravity, Water Absorption.

iii) Conclusions on qualities and quantities.

(3) Where the Contractor uses a rock quarry, quarry, alluvial deposit, or a borrow pit identified or instructed by the Engineer he shall obtain the Engineer's approval of the areas required for the rock quarry, quarry, alluvial deposit, or borrow pit and of the siting of the access roads into the rock quarry, quarry, alluvial deposit, or borrow pit. The Engineer may required the Contractor to modify his requirements for any of the reasons outlined in Sub-clause 803 (1) (a), (b), (c), (d) or (f).

Where rock quarries, quarries, alluvial deposits, or borrow pits, available for inspection at the time of the Tender, are instructed by the Engineer the Contractor shall satisfy himself as to the quality and quantity of materials available before providing the information required in this Clause. Should such investigations reveal tat there is insufficient suitable material for the use for which such material sources were intended, the Contractor shall immediately inform the Engineer in writing and the Engineer shall either direct that such sources are extended or that new sources shall be used.

(4) When a rock quarry, quarry, alluvial deposit, borrow pit spoil or stockpile area has insufficient suitable material or area for the use for which it was intended the Contractor shall propose in writing that either any existing rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area be extended or that a new rock quarry, quarry, alluvial deposit, borrow pit spoil or stockpile area shall be used. The approval and acquisition of such new or extended rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas shall in accordance with all the above provisions of this Clause for the acquisition of the original rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas.

804. SAFETY AND PUBLIC HEALTH REQUIREMENTS

The Contractor shall comply with the prevalent laws and Regulations including those of the Local Authority regarding public health and safety in respect of the operation of rock quarries, quarries, alluvial deposit, borrow pits, spoil or stockpile areas, and in the absence of, or in addition to such Regulations, shall comply with the following conditions :-

(1) All areas of work, if they are not naturally under water, shall be drained and kept drained where a quarry or borrow pit has been excavated such that it will not drain naturally, it shall be kept pumped dry while being used.

(2) The Contractor shall confine his operations solely to the areas provided and shall demarcate the boundary of the area and erect temporary or permanent fencing as instructed by the Engineer.

(3) Where the height of any face exceeds 1 metre, the Contractor shall provide, erect and maintain at his own expense stock proof fencing and gates to prevent unauthorized access to the top of the working face.

(4) On completion of the work all faces shall be neatly trimmed to a slope flatter than 1:4. Where this is impracticable or where the working face is to be left exposed, the edge shall be permanently fenced, as instructed by the Engineer and measurement and payment for such fencing shall be in accordance with Section 400.

(5) On completion of work temporary fences and all temporary structures shall be demolished and removed. All latrine pits shall be filled in and drained. The site shall be topsoiled and left neat and tidy.

805. ACCESS ROADS AND TRAFFIC CONTROL

The Contractor shall comply with the provisions of Clause 103 and with the Conditions of Contract with regard to the construction and maintenance of access roads to rock quarries, quarries, alluvial deposits, borrow pits spoil and stockpile areas and with regard to traffic operations thereon.

806. SITE CLEARANCE AND REMOVAL OF TOPSOIL AND OVERBURDEN

Unless otherwise specified in the contract or instructed by the Engineer, the Contractor shall clear the sites of all rock quarries, quarries, alluvial deposits, borrow pits, spoil and stockpile areas in accordance with Section 200 but measurement and payment shall be made in accordance with this Section. All existing fences, tree, hedges and other features which the Engineer shall instruct shall not be removed or otherwise dealt. They shall be protected in accordance with Section 200.

Unless otherwise directed by the Engineer, the Contractor shall remove topsoil and/or overburden from rock quarries, quarries, alluvial deposits, borrow pits and spoil and stockpile areas. The Engineer shall direct whether topsoil shall be stripped and stockpiled separately or shall be excavated and spoiled together with the overburden. If suitable, the Engineer may direct for the use of overburden in the works.

On completion of the work in any rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area the overburden and/or topsoil which has not been used in the works shall be pushed back, spread and landscaped over the area of the rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area. Where topsoil has been stockpiled separately, it shall be pushed back and spared over the rock quarry, quarry, alluvial deposit, borrow pit, spoil or stockpile area after landscaping unless the Engineer has instructed that it shall be used for topsoiling in accordance with Section 600.

807. SELECTION, MIXING AND STOCKPILING OF MATERIALS

Before a quarry, alluvial deposit or borrow pit is opened, the Engineer shall instruct the Contractor as to the type of material to be excavated and the areas and depth to be worked. The Engineer may require specific operations of equipment according to the characteristics of the raw material and the characteristics of the final product to be obtained in accordance with Clause 808 and 809 or other relevant Section of those Specifications.

The Contractor may be required to mix selected material by bulldozing into stockpiles and/or face loading by shovel. The stockpiles shall be formed at least six weeks before intended use of the material which are to be treated and at least three weeks before intended use for materials which are not to be treated.

The Contractor shall ensure that oversize material, clay humus or unsuitable material encountered in the working operations is separated from the materials proposed for use in the works and such inferior material shall be removed tot spoil.

A separate stockpile shall be used for each type and grading of material.

When removing material from stockpiles, none of the underlying material shall be mixed with it, and generally at least the bottom 100 mm layer shall be left behind.

Should any stockpile prove surplus to requirements, the Contractor shall spread the material over the area of the quarry or borrow pit unless directed otherwise by the Engineer.

808. PRE-SELECTION OF MATERIALS

When necessary to meet requirements of the Specifications for materials extracted from quarries or alluvial deposits the Contractor shall carry out a preliminary size selection or screening of the raw material as follows:

(1) Size Selection

The size selection shall be carried out by unloading the material through appropriate grids to select the size fraction which contains the required fraction of the required type of stone specified in the Specifications, based on the identification of the petrographic composition of the various size classes of the raw material through laboratory trials in accordance with Clause 506.

The size selection shall be carried out provided the conditions given in Table 8.1 are fulfilled where:

R_p (%) = the minimal ratio between the quantity of required material obtained after processing (including selection, crushing, screening etc.) and the initial quantity of raw material treated.

Q min (m^3) = the minimal quantity of processed materials of such type required for the works.

A, B, = Classes of material to be produced designated in accordance with the General Classification of materials specified in Section 600.

Table 8.1: Conditions for Pre-selection of Size

Quality classes to be produced	Construction Work		Maintenance works	
	R_p (%)	Q min (m^3)	R_p (%)	Q min (m^3)
A	40	7,500	35	4,000
B	70	85,000	60	20,000

(2) Quality Control of the Size Selection

Materials of quality classes A or B shall be tested according to their use in conformance with the relevant Sections of these Specifications.

When the requirements of the final products are not met, the Engineer may require the Contractor to control the quality of the size selection.

The quality of the size selection shall be assessed by sampling 1000 boulders or stone in every 500 m^3 of pre-selected material and counting the boulders or stones of the required petrographic types. If the percentage of such boulders or stones in the sample is less than 0.8 of the expected percentage, the corresponding pre-selected materials shall be pre-selected again.

809. PROCESSING

The Contractor shall use adequate processing equipment and methods to achieve the characteristics and performance of the aggregates to be produced.

The processing methods may include successive steps such as primary crushing, screening for elimination of fine and soft material, secondary crushing and recycling, washing.

The Contractor shall carry out site trials in accordance with Clause 507 using the Constructional Plant and methods proposed for selecting and processing the materials to demonstrate their suitability to achieve the material requirements specified in the Specifications.

(1) Crushing

The crushing process shall include all crushing stages, such as primary crushing, secondary crushing or grinding (after primary screening) tertiary grinding (after secondary screening), as necessary to meet the requirement of the final product specified in the Specifications.

The feeding hoppers shall be equipped with appropriate devices, such as drawer or vibrating metallic desk, to allow for a regular and full charge supply of the material to the crushers.

Depending on the type, size and characteristics of the raw material, equipment required to meet aggregate characteristic and performances requirements may include the use of equipment given in Table 8-2 according to the classes of quality of the materials to be produced.

Table 8.2: Crushing Equipment According to Quality Classes of Final Material Product.

Quality classes of the final product	Type of equipment		
	Primary crushing	**Secondary crushing or grinding**	**Tertiary Grinding**
A or B			
In general	▪ Jaw Crusher or Gyratory Crusher (for more than 1000T/h only)	▪ Cone Grinder or Gyratory Grinder (for more than 1000T/h only)	
Quartzite & Sand Production	▪ Gyratory Crusher (for more than 1000T/h only)	▪ Cone Grinder or Gyratory Grinder	▪ Cone Grinder (Gyradisc)
Limestone	▪ Jaw Crusher or Large Opening Percussion Crusher	▪ Impact Crusher (& recycling)	
C1	▪ Jaw Crusher	▪ Cone Grinder (& recycling)	
D1	▪ Jaw Crusher	▪ (& recycling)	

(2) Screening

The Contractor shall eliminate polluted or soft materials after the primary crushing by screening the crushed materials through a 50 mm mesh screen.

The Engineer may instruct the Contractor to modify the above mentioned size for the elimination of soft materials according to the results of the laboratory trials.
In case of materials sensitive to crushing, the Engineer may instruct the Contractor to carry out a secondary screening after the secondary crushing.

(3) Recycling and Sand Production

According to the type and quality of materials to be produced, and notably the sand materials, the Contractor shall include in the crushing process the recycling of the coarse fraction resulting from the primary crushing through the secondary crusher or through the secondary or tertiary grinder.

(4) Washing

Where the washing of aggregate is required to meet the cleanliness requirements, and notable for the chippings for surface dressing, the Contractor shall incorporate to the processing plant an appropriate washing station including adequate equipment such as vibratory washing machine, a washing screw, washing tube etc. and of adequate capacity.

Sand with too high mica content shall be washed using appropriate equipment such as screw classifiers, paddle wheel etc.

(5) Testing

Each type of final products shall be tested in accordance with the tests and frequencies of testing as specified in the relevant Sections of these Specifications.

(6) Records

The Contractor shall maintain records in respect of the following data throughout the production period:

(a) daily production
(b) testing result, in accordance with the test schedules specified in the relevant Sections of these Specifications.
(c) Incident occurred during the production, if any.

810. MATERIAL UTILISATION

All materials from rock quarries, quarries, alluvial deposits, borrow pits as instructed by the Engineer shall only be used for permanent works shown on the Drawing or instructed by the Engineer and any other use shall be subject to the Engineer's approval.

811. MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made in respect of all items in this Section, if otherwise not specified in the contract. The Contractor shall be deemed to have allowed the cost of complying all requirements of this Section elsewhere in his rates including al site clearance, overburden and topsoil removal, access roads to rock quarries, quarries, alluvial deposits, borrow pits, spoil or stockpile areas and reinstatement including landscaping and spreading topsoil.

Where the Engineer has instructed that overburden or topsoil will be used in the works, measurement and payment shall be in accordance with the relevant Sections of these Specifications.

SECTION 900 – EARTHWORKS

SECTION 900 – EARTHWORKS

901. SCOPE

This section covers the works related to the roadway excavation, roadway filling, excavation for foundation, backfilling, excavation for drains, channels, intercepting drains etc.

902. DEFINITIONS AND GENERAL REQUIREMENTS

(1) Earthwork includes two types of operations i.e. (i) earth excavation and disposal of the excavated materials (ii) earth excavation and use of excavated materials. The use of excavated material may be in the form of filling embankment, backfilling, filling other areas as required.

Earth excavation and disposal implies excavation of all types of materials including part of the structures below ground level within and outside of the limit of the right of way except for otherwise specified, shaping the exposed surface of excavation as specified or directed by the Engineer, removal, hauling and disposal of the excavated material at the locations and in the manner as specified or directed by the Engineer.

Excavation and filling implies excavation of materials and shaping the exposed surface of excavated as stated, removal hauling and use of the excavated material at the location and in the manner as specified or directed by the Engineer.

Excavation and disposal shall include:

(i) Excavation and disposal of any type of material included on the Drawing.
(ii) The excavation and disposal of existing surfacing.
(iii) Excavation and disposal of slides, breakages and caving-ins.
(iv) Excavation and disposal for stream channel, trenches and drains etc.
(v) Excavation required in cuts or under embankments below the lowest normal limit of excavation as indicated on the Drawing or below ground line.
(vi) Excavation and disposal of unsuitable materials.
(vii) Removal or partial removal of existing embankments and disposal of the materials as shown on the Drawing or as directed by the Engineer.
(viii) Excavation for foundation and disposal of materials.

Excavation and filling shall include:

(i) Filling for embankment
(ii) Filling for guide bunds, coffer dams, etc.
(iii) Backfilling in trenches, foundation pits etc.

(iv) Any type of other filling or backfilling whereby the ground level is raised or a hole is filled up.

(2) The following definitions of earthworks materials shall apply to this and other Clauses of these specifications, if otherwise not specified.

(i) "Topsoil" shall mean the top layer of soil that can support vegetation. It shall include all turf acceptable for turfing.

(ii) "Suitable Material" shall comprise all that is acceptable in the accordance with the Contract for use in the Works and which is capable of being compacted in the manner specified in Clause 909 and 910 to form a stable fill having side slopes as indicated in the Drawing. The material used in fill (except for rock fill) shall not contain rock fragments with dimensions of more than 75 mm.

(iii) "Unsuitable Material" shall mean other than suitable material and shall include:

(a) Material from swamp, marshes or bogs;
(b) Peat, logs, stumps, perishable material, organic clays;
(c) Material susceptible to spontaneous combustion;
(d) Material in a frozen condition;
(e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45;

Material stated above in (d) if otherwise suitable shall be classified suitable when unfrozen.

(iv) "Rock Fill" shall consist of hard material of suitable size for deposition and compaction as given in Clause 909 and also may comprise rock as defined in Clause 903 and broken stones.

(v) "Well Graded Granular Material" consisting of gravel and/or sand shall conform to Clause 609.

(3) No excavated suitable material other than surplus to requirements of the contract shall be removed from the site except on the direction of the Engineer. Should the Contractor be permitted to remove suitable material from Site to suit his operational procedure, then he shall make good at this own expense any consequent deficit of filling arising therefrom.

(4) Material in surplus to the total requirements of works, and all unsuitable material shall, unless the Engineer permits otherwise, be run to spoil dumps.

(5) Where the excavation reveals a combination of suitable and unsuitable materials the Contractor shall carry out the excavation in such a manner that the suitable materials are excavated separately for use in the works without contamination by the unsuitable materials.

(6) The Contractor shall make his own arrangements for the stockpiling of top-soil and/or suitable material.

(7) At all times the Contractor shall ensure that earthworks are not damaged by weather or traffic. In event of such damage, the Engineer may withdraw approval from the affected works until the Contractor has carried out repairs to restore the works to their original condition.

The cost of all such repairs and any additional testing shall be borne by the Contractor.

(8) Prior to commencement of any earthwork, the work shall be set out where required as specified in Clause 104 following the clearing and grubbing as per Section 200 and survey of the existing ground shall be conducted jointly by the Contractor and the Engineer. The survey records shall serve as initial measurements for the determination of the final quantities of earthwork performed under the contract.

(9) Works on embankments and/or cutting in areas required for the construction of bridges and other structures shall not be carried out until the Engineer agrees that construction of such structures is sufficiently advanced that there is no interference or damage to them.

(10) The Contractor shall get approval of the Engineer in respect of method of earthwork, type of equipment to be used, disposal and other details before commencement of the earthwork.

903. CLASSIFICATION OF EXCAVATED MATERIALS

The excavated materials shall be classified under the following categories. The decision of the Engineer in respect of the classification of excavated materials shall be the final and binding upon the Contractor.

(1) Soft Soil

It shall mean soft soil comprising any of the following:

(a) Vegetable or organic soil, turf, sand, loam clay, mud, peat, black cotton soil, stiff heavy clay, shale, moorum and any mixture of these soil.

(b) Mud concrete below ground level.

(c) Generally any material which yields to the ordinary application of pick and shovel or other digging implements.

(2) Hard Soil

It shall mean hard soil comprising any of the following:

(a) Gravel, shingle and river or stream bed boulders having maximum dimensions up to 300 mm in one direction.

(b) Soling of roads, paths, etc. and hard core, macadam surfaces of any description (water bound, grouted, bituminous surface etc.)

(c) Lime concrete, stone masonry in lime mortar and brick work in lime cement mortar below ground level.

(d) Generally material which requires the close application of picks, scarifiers or other digging implement.

(3) Soft Rock

It shall mean rock comprising any of the following:

(a) Lime stone, sand stone, late rite, soft conglomerate or other soft or disintegrated rock which can be quarried or split with crowbars or wedges.

(b) Unreinforced Portland cement concrete which can be broken up with crowbars or picks; stone or brick masonry in cement mortar below ground level.

(4) Hard Rock

It shall mean rock comprising any of the following:

(a) Any rock or Portland cement concrete for the excavation of which the use of pneumatic/mechanical equipment or blasting is required.

(b) Reinforced cement concrete (reinforcement cut through, but not separated from the concrete)below ground level.

(5) Hard Rock (Blasting Prohibited)

It shall mean rock comprising any of the above mentioned hard rock where blasting is prohibited.

904. EXPLOSIVES AND BLASTING

(1) General

The procurement, transportation, storage, use, account and disposal of balance and defective explosive materials shall be strictly as per prevalent laws and ordinances applicable to the work site. Should there be any discrepancy found between procedures described hereunder and the prevalent laws and ordinance, the later shall supersede.

Blasting shall be carried out in a manner that completes the excavation to the lines indicated on the Drawing or as directed by the Engineer, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer.

The Contractor shall adopt such method that is consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

(2) Material, Tools and Equipment

All the material, tools and equipment used for blasting operations shall be off approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be water-resistant and shall remain unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as shall permit sufficient time tot eh firer to reach to a safe place before explosion takes place. Detonators shall be capable for giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use. The damaged articles, if any, shall be discarded totally and removed from the site immediately.

(3) Personnel

The blasting operation shall remain in the charge of competent and experienced blaster with legal license and thorough knowledge of handling explosives and blasting operations.

(4) Blasting Operations

Explosives shall be used in the quantities and manner recommended by the manufactures. The written permission of the Engineer shall be obtained for each location or series of locations where the Contractor wishes to use more than 5 kg of explosives in one series of blast. Such permission shall not any way relieve the Contractor of his liabilities under the Conditions of Contract.

The blasting shall be carried out during fixed hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the blaster only.

The Engineer must be notified at least 24 hours in advance on any blasting operation. When blasting is to be carried out, the Contractor shall determine the danger zone likely to be created, and shall ensure that all personnel, vehicles and livestock are clear of the zone before and during the blast. In settled areas, the Contractor shall take steps to avoid damage to property from flying rock by using blasting mats or other suitable blanketing materials.

The Contractor shall notify each public utility organization/company having structures in proximity to the site to the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury.

Danger red flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area, and all persons including workmen shall be excluded form the flagged area at least 10 minutes before the firing, a warning siren being sounded for the purpose.

The charge holes shall be drilled to required depths and at suitable places. Blasting shall be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued. Not more than 10 charges shall be prepared and fired at a time. The man in charge shall blow a siren in a recognized manner for cautioning the people. The charges shall be lighted by the blasters only. The blaster shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workmen to go back to the work site.

After blasting operations, the Contractor shall compact the loose residual material removed below sub-grade and replace the material removed below sub-grade with suitable material.

When forming final cut faces, pre-split blasting techniques as recommended in the Specification for Road and Bridge (IRC) shall be carried out to ensure that blasting damaged to the cut face is minimized. Details of the pre-splitting technique to be used shall be notified to and approved by the Engineer at least 24 hours in advance of the blasting operation.

(5) Misfire

In case of misfire, the following procedure shall be observed:

(a) Sufficient time shall be allowed to account for the delayed blast. The blaster shall inspect all the charges and determine the missed charge.

(b) If it is blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. Should it not blast the old charge, the procedure shall be repeated till the old charge is blasted.

(c) In case of charges of gelignite, the blaster shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 30 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired hole should explode at the same time. The blaster shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.

If a misfire had been found to be due to defective detonator or gelignite/dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority as directed by the Engineer for inspection to ascertain whether all or art of the remaining materials in the box are also defective.

(6) Account

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times. Records must be kept by the Contractor of all drilling and blasting operations showing holes diameters and depths, drilling pattern, explosive charge and type per hole, detonator delay times and total charge per blast. These records must be submitted to the Engineer on completion of charging.

905. EXCAVATION IN CUTTING

(1) Cleaning and grubbing shall be performed as specified in Section 200.

(2) While executing excavations, the Contractor shall take adequate precautions against soil erosion and water pollution.

(3) All suitable excavated materials shall be used in construction of the roadway to the extent as required.

(4) Hauling of material from cutting or borrow pits to embankments other areas of fill shall proceed only when plant or labour is operating at the place of deposition to ensure that adequate spreading and compaction of material can take place.

(5) Over-excavation shall not be permitted. Any excess depth excavated below the formation levels as specified shall be made good by the Contractor at his own expense by backfilling with suitable material of similar characteristics to those of moved materials with compaction as specified in Clauses 909 and 910.

(6) The slopes of cutting shall be cleared of all rock fragments which move when prised by a crowbar, unless otherwise directed by the Engineer. Where the Engineer considers that the slope, immediately after dressing, shall not be permanently stable, he shall direct the Contractor as to the stabilization measures required. The Contractor shall carry out these measures soon after Engineer's instruction.

When completed, the excavation slopes shall be true to the lines and levels as shown on the Drawing or directed by the Engineer. When completed, no point on slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock, no point shall vary more than 300 mm from the designated slope.

(7) If slips, slides, over breaks or subsidence occur in cutting, they shall be removed. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction.

(8) If water is encountered in excavations due to seepage, springs, or other causes, it shall be removed by suitable diversions or bailing out and the excavation shall be kept dry. The drained water shall be discharged into suitable outlets as not to damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.

906. EXCAVATION BELOW EMBANKMENTS AND BELOW FORMATION LEVEL

(1) Where any unsuitable material below the natural ground level under proposed embankments or below formation level in cutting is required to be excavated, it shall be removed to such depth and over such areas as shown on the Drawing or as directed by the Engineer. The excavated materials shall be disposed off as indicated on the Drawing or directed by the Engineer. The resultant excavation shall be backfilled with suitable material and shall be leveled and compacted to the density as specified for forming of the embankments.

Nevertheless, if such backfill has to be carried out in standing water, the Contractor shall use only an approved non-plastic well-graded granular material having maximum size of not greater than 75 mm. Such materials may be deposited in water without use of compaction equipment.

(2) Where shown on the Drawing, approved, graded stones having size from 380 mm to 150 mm and containing not more than 10 percent, below 150 mm in size shall be placed directly on the natural occurring unsuitable material. This type of rock fill material shall be deposited in accordance with the requirements of Clause 909 and compacted as per Clause 910.

(3) If after the removal of material as specified in Sub-clause 906 (1), the Contractor allows the materials so exposed to reach a condition where compaction of back filling is impracticable, he shall make good at his own expense either by additional excavation and filling in the manner specified in this Clause, or by waiting until the condition of the exposed material is fit to receive the approved backfill.

907. EXCAVATION FOR FOUNDATION

(1) Slope

Excavation shall consist of the removal of material for the construction of foundations for drainage structures, retaining walls, head walls, cut off walls, culvert, bridges and other similar structures to the lines and dimensions shown on the Drawing or as instructed by the Engineer in accordance with the requirements of these specifications. The work shall include construction of the necessary cofferdams and cribs and subsequent removal of all necessary sheeting, shoring, bracing, diversion of water/flow, draining and pumping, the removal of all logs, stumps, grubs and other deleterious matters and obstructions necessary for placing the foundation; trimming bottoms of excavations; and cleaning up the site and the disposal of all surplus material.

(2) Excavation

Excavation shall be taken to the length and width of the lowest step of the footing and the sides shall be left to plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench does not permit vertical sides, the Contractor at his own expense shall put up necessary shoring, strutting and planking or cut slopes to a safer to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The depth to which the excavation is to be carried out shall be as shown on the Drawing or as directed by the Engineer.

Where blasting is to be restored to, the same shall be carried out in accordance with Clause 904.

(3) Dewatering, Diversion of Flow and Protection

Normally, open foundation shall be laid dry. Where water is encountered in excavation due to stream flow, seepage, spring, rain or other reasons, the Contractor shall take adequate measure such as bailing, pumping, constructing diversion channels, drainage channels, bunds, cofferdams and other necessary works to keep the foundation pit or trenches dry, when so required and to protect the green concrete/masonry against damage by erosion, failure of cut slope or sudden rising of water level. The methods to be adopted in this regard and other details thereof shall be left to the choice of the Contractor, but subject to approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of the Engineer shall, however, not relieve the Contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Where cofferdams are required, these shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipment, etc., inside the enclosed area.

Cofferdam sheet-pilling shall be carried down well below the bottom of the pile caps or footings, but without interference with any bearing piles. Cofferdams shall be rigidly constructed and efficiently braced to withstand external pressures when water is pumped out. Sheeting shall be reasonably watertight and all appreciable leaks encountered during the operations shall be stopped so that construction of pile caps can be carried out in the dry. The Contractor shall rectify any cofferdam which, for any reason, has moved, tilted, or changed its shape and/or size.

Pumping form the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it is done from a suitable sump and is separated from the concrete work by a watertight wall or other similar means.

At the discretion of the Contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the area of excavation.

The Contractor shall take all precautions in diverting flow and in discharging the drained water as not to cause damage to the works, crops or any other property. If any such damage is caused due to any negligence of the Contractor, it shall be the sole responsibility of the Contractor to repair/restore to the original at his own cost or compensate for the damage.

(4) Preparation of Foundation Base

The bottom of the foundation pit shall be leveled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed, if surface is not wet. In the event of excavation having been made deeper than that shown on the Drawing or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete or masonry of the foundation grade at the cost of the Contractor. Ordinary filling shall not be allowed for the purpose to bring the foundation to level. When rock or other hard strata is encountered, it shall be freed of all soft and loose materials, cleaned and cut to firm surface either leveled or stepped as directed by the Engineer. All seams shall be cleaned out and filled with cement mortar or grout to the satisfaction of the Engineer. In the case of rock excavation, annular space around footing shall be filled with concrete of grade M 10 up to top level of rock.

After the excavation is completed, the Contractor shall inform the Engineer to that effect and no footing, bedding materials or structures shall be placed until the Engineer has approved the depth and the suitability of foundation material.

If, at any point, in any foundation excavation, material unsuitable for foundations is encountered, the Contractor shall, if so instructed by the Engineer, shall remove all such materials and refill with suitable materials thoroughly compacted by tamping or rolling in layers of not more than 150 mm thick each.

(5) Slips and Blows

If there are any slips or blows in the excavation, these shall be removed by the Contractor at his own cost.

(6) Public Safety

Where required, trenches and foundations pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accident as per Sub-clause 102 (5).

The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures.

(7) Removal of Cofferdams

All cofferdams with all temporary sheeting and bracing shall be removed by the Contractor after the completion of the substructure unit. The removal shall be carried out in such a manner as not to disturb or damage the finished concrete. However, sheet pilling below the top of the pile caps may be left in place at the Contractor’s option and expenses.

No bracing no other material shall be left in cofferdam in such a way as to extend into the concrete of the structure.

Cofferdam located in embankments under the roadways shall be removed to an elevation at least 1.2 m below the subgrade. Those located in a stream or lake and within the limits of low water shall be removed to the elevation of the stream or lake bed, except that in established navigation channels, they shall be removed to an elevation at least 600 mm below t he established bottom of the channel. Those located outside the above defined limits shall be removed to an elevation at least 600 mm below subgrade.

908. REFILING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLING TO STRUCTURES

Refilling of foundation pits and trenches shall consist of previous backfill and/or common backfill as shown on the Drawing or as directed by the Engineer.

(1) Materials

(a) Pervious Backfill

Unless otherwise specified in the contract, it shall of gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof. It shall conform to the grading limits set out in Table 9.1.

Table 9.1: Grading Limits of Pervious Backfill

Sieve Size (mm)	Percentage Passing by Weight
40	100
10	45-100
2.36	25-80
0.60	8-48
0.075	0-6

(b) Common Backfill

Common backfill materials other than pervious backfill shall be suitable material as defined in Sub-clause 902 (2).

(2) Method of Filling

Backfilling material shall not be permitted under water unless specifically described in the contract or approved by the Engineer. It shall be placed and compacted in layers in compliance with the requirements of Clause 910. Any support structures for the excavation shall be withdrawn as the filling proceeds unless described in the contract or ordered by the Engineer to be left in. The backfill shall be placed in by such methods which shall avoid loading the structure in any manner which may affect its stability or overload its underlying foundation material or substructure. The backfill in front of abutments and wing walls shall be placed first to avoid the

possibility of forward movement. Precautions shall be taken to prevent any wedge action against upright surfaces, and the slopes bounding the excavation shall be stepped as directed by the Engineer before backfill is placed. The backfill material around box culverts, piers and curtain walls shall be placed simultaneously on both sides of the structure. When the structure is so designed that its strength is dependent on the restraining effect of the superstructure (such as in portal frames and propped abutments), the backfill shall not be placed until the superstructure has been completed to the extent and strength necessary to provide the required restraint. When the Contract requires wedges between steel superstructure and the parapet of wing type abutments, the wedges shall be placed in advance of placing any fill above the lower 1/3 of the abutment and shall be removed when directed by the Engineer.

909. FORMING OF EMBANKMENT AND OTHERS AREAS OF FILL

(1) The work shall consist of the construction of embankment, filling on other areas and backfill not specified elsewhere by providing material as specified or approved by the Engineer, placing, compacting and shaping to lines, levels, grades and cross sections as shown on the Drawing or as directed by the Engineer. The maximum size of the coarse material in the mixture shall not exceed 75 mm for general earth fill.

(2) The limits of embankment shall be built sufficiently wider than the design dimension to facilitate in achieving required compaction near by outer faces of the embankment. The surplus material shall be trimmed to conform the specified side slopes and width of the embankment.

(3) Where necessary, the original ground shall be scarified, mixed with water, leveled and then compacted so as to achieve the density mentioned in Clause 910. Where the height of embankment, as measured from formation level to the original ground level, is less than 200 mm, the embankment foundation shall be compacted in accordance with the requirements of Clause 910 such that the required compaction is achieved within the upper 300 mm below formation level. Where necessary, embankment foundations shall be excavated/furrowed and brought under OMC and re-compacted in layers of 150 mm each in order to achieve the required level of compaction.

(4) Embankments shall be built up evenly over the entire width and shall be maintained at all times with a sufficient camber to enable surface water to drain rapidly from them. Damage to compacted layers by constructional or other traffic shall be made good by the Contractor.

(5) The natural moisture content and the optimum moisture content of the material to be placed in the embankment shall be checked before start of the placing material. If found to be out of the specified limits, the same shall be made good. Where water is required to be added in such constructions,

water shall be sprinkled uniformly and thoroughly mixed in soil by blading or harrowing until a uniform moisture content as specified is obtained.

Moisture content, checked in accordance with IS 2720 (Part 2), at the time of compaction shall be between 90% and 105% of the Optimum Moisture Content as determined in accordance with IS 2720 (Part 8).

If the material delivered for fill/backfill is too wet, it shall be dried by aeration and exposure to sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced by the above procedure, compaction work shall be suspended.

If the material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the requirements of the specifications the Contractor shall

(i) Make good by removing the material off the embankment and placing suitable material; or

(ii) Make good by tipping it elsewhere it elsewhere until it is in a suitable physical condition for re-use; or

(iii) Make good the material by mechanical or chemical means to improve it's properties acceptable to the Engineer.

(6) Where fill is required to be constructed across water logged or soft clayey ground that displays excessive movement under normal constructional equipment, it may be necessary to construct a capping layer in accordance with Clause 1004.

(7) Rock use in rock fill embankments shall be deposited in horizontal layers not exceeding 450 mm each extending up to the full width of the embankment.

Material shall be spread, leveled and compacted in accordance with Clause 910. Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. The top surface and side slopes of embankments so formed shall be thoroughly blinded with approved well graded material to seal the surface.

(8) Isolated boulders each within the range of0.05 cubic meters in size may be incorporated in embankments, not of rock fill, at the discretion of the Engineer provided that the specified compaction requirements are met and it shall not be placed less than 1 m below formation level of carriageways or shoulders.

(9) While filling embankment up to or over culverts or pipe drains, and where required in the contract, up to bridges, the Contractor shall bring the

embankments up equally on both sides. In rock fill embankments the rock shall be carefully packed for such distance form the structure as is described in the contract.

Where provision of filter membrane is specified behind structures, the same shall be laid in layers simultaneously with the laying of fill material.

(10) If the Contractor wishes to continue to use the surface of embankments including shallow filling for constructional traffic before trimming to formation level, he shall bring up and maintain the area between the extremities of the carriageway including (if any) central reserve and hard shoulders to a level not less than 150 mm above formation level whereupon constructional traffic shall be allowed to use the surface and shall be made good by the Contractor at his own expense. When it is necessary to complete the formation level and this has been done, the movement and use of construction equipment thereon shall be in accordance with Clause 1103.

910. COMPACTION OF EMBANKMENT AND OTHER AREAS OF FILL/BACKFILL

(1) The Contractor shall obtain the Engineer approval of all fill layers before covering with subsequent layers.

(2) All fill shall be compacted to the depth and degree of compaction as specified in Table 9.2 or as shown on the Drawing. This requirement applies whether the specified zone is in fill or in existing ground, except for any part which may fall within rock or rockfill. Formation level if this context shall mean top of subgrade.

Table 9.2: Compaction Requirements

Location	Depth below Formation Level (mm)	Minimum Compaction (% MDD Heavy Compaction)
Roadway Embankment	0-300	95
Roadway Cut	0-300	95
All other roadway fill and backfill not separately specified	-	93

(3) Each layer of rock used to fill in embankments shall be spread and leveled in accordance with Sub-clause 909 (7) and systematically compacted.

(4) Layers of material other than rockfill shall not exceed 150 mm compacted depth unless and until the Contractor can demonstrate to the satisfaction of the Engineer that he can successfully Compact layers of a greater thickness.

(5) Each layer shall be constructed in lengths suitable to the compaction and working methods used. Materials of each layer shall be thoroughly mixed with water as necessary to facilitate its compaction to the specified density.

(6) In cut areas, the subgrade shall be processed as necessary and compacted to the depth and compaction requirements as given in Table 9.2. In the event that the Contractor is unable to achieve the minimum compaction requirements below formation level he shall excavate and recompact in layer as necessary.

(7) Where it may be impracticable to use to conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory rollers, power rammers or plate compactor. Care shall be taken to ensure that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to it.

911. COMPACTION TRIALS

(1) Before commencing filling embankment and from time to time as may be considered necessary by the Engineer, the Contractor shall carry out compaction trials in the presence of the Engineer on each of the main types of soil and rockfill to be used and compacted in the Works. He shall carry out all necessary laboratory and field testing as required by the Engineer and shall submit to the Engineer the results of all tests. The trial procedure shall include the compaction of trial areas selected by the Engineer. The surface of each area shall first be well compacted to the satisfaction of the Engineer. Each type of material being used shall be compacted in equal layers at uniform but differing moisture contents to a predetermined number of passes using the Contractor's proposed compaction equipment.

(2) Following completion of the compaction trials, the Contractor shall submit to the Engineer, for his approval, his proposals for the compaction of each type of material to be encountered in the Works and its degree of compaction specified. The Contractor's proposals shall include reference to the types of equipment, the operating weights and type pressure, the methods of adjusting the moisture content, the number of passes and the loose depth of each layer.

(3) If, in the opinion of the Engineer, the results of the compaction trials indicate that the Contractor's proposed plant and methods shall achieve the densities as specified, the Engineer shall approve the same. Otherwise the Contractor shall submit, in writing, proposals for modifying the plant and/or methods and shall, if the Engineer so requires, compact further trial areas in

accordance with these modified proposals until the Engineer approves of Contractor's proposals.

(4) When compaction of earthworks is in progress, the Contractor shall adhere to the compaction procedure approved by the Engineer.

(5) Notwithstanding the Engineer's approval of any of the Contractor's plant or methods, the Contractor shall at all times be solely responsible for executing the earthworks in accordance with the Specifications and the Drawing.

912. BENCHING

(1) Where embankment are to be constructed on hill slopes or slopes with more than or equal to 1 vertical to 4 horizontal slopes, benches with vertical and horizontal faces shall be cut into the existing slope (including rock) and the embankment shall be built up in successive layers. Where the cross slope is less than 1 vertical to 4 horizontal slope (other than rock) shall be loosened by scarifying to a depth of not less than 100 mm measured perpendicular to the slope, to ensure a good bond between the embankment and the embankment foundation. Material which has been loosened shall be covered with he first layer and compacted to the specified density simultaneously with the first layer of embankment material placed.

(2) Where existing embankment are to be widened or included in a new embankment and slopes are not more than 1 vertical to 4 horizontal, the slope of the existing embankment shall be scarified to a depth of not less than 100 mm to ensure bond. Where the slope is less than 1 vertical to 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut in existing slopes and the widened embankment shall be built up in successive layers of thickness of 150 mm to the level of old road.

Where the width of the widened portions is insufficient to permit the use of heavy rollers, compaction to the specified density shall be carried out with the help of small vibratory roller/plate compactor/rammer or other approved methods.

913. EARTHWORKS TO BE KEPT FREE OF WATER

By providing temporary water course, ditches, drains, pumping or other means the Contractor shall arrange for the rapid dispersal of water from the areas of earthworks. Where practicable the water shall be discharged into permanent outfall for the drainage system. Adequate means for trapping silt shall be provided on temporary systems while discharging into permanent drainage systems.

914. WATERCOURSES

Excavations carried out in the diversion, enlargement, deepening or straightening of watercourses shall include the operations of any necessary trimming of slopes, grading of beds, disposal of excavated materials and pumping, tampering works and materials necessary for dealing with the flow of water.

915. FILLING EXISTING WATERCOURSES

Where watercourses have to be diverted from the sites of embankments or other works, the original channels shall be cleared of all vegetable growths and soft deposits and filled in with suitable materials deposited and compacted as specified in Clauses 909 and 910.

916. PROCESS CONTROL

(1) Through out the works the Contractor shall perform tests to determine the suitability and compaction characteristics of soils to be used in roadway. The compaction test shall be conducted in accordance with IS 2720 Part 8 in every 1500 cubic metre of fill material and every change in material type. The moisture content test shall be conducted in accordance with IS 2720 Part 2 in every 250 cubic metre of material.

(2) In addition to the foregoing tests, the Contractor shall carry out fiekd density tests on the compacted fill materials in accordance with IS 2720 part 28/29. At least one set of density determination consisting of three tests per 500 square metres (or any lesser area) shall be carried out in each layer, including original ground surface on which embankment is to be constructed. If the result of any test shows that the minimum specified density has not been achieved, further compaction shall be executed to the area concerned and the layer re-tested. Unless the test results are satisfactory, the addition of another layer shall not be allowed.

(3) The Contractor shall carry out tests for determination of moisture content at frequent intervals on all materials during the course of compaction as per Sub-clause 909 (5) to ensure that the requirements of Clause 910 are met with.

917. MEASUREMNT

(1) The quantities of the various classes of earthwork to be measured for payment under the contract shall be limited to the lines, grades, slopes and dimensions shown on the Drawing or as determined by the Engineer.

(2) Except for foundation, all roadway excavation including side drains, filling and backfilling compacted in place shall be measured in cubic metres by the

average end area method as computed from the original and final cross-sections of the completed work. The distance between two end areas shall be the distance measured along central line of the road. Where due to changed conditions, or the nature of a particular operation, or for any other reason, it is impossible or impractical to measure the quantities by means of average end areas, the Engineer shall compute the quantities by a volumetric method, if in his opinion, it is the best suited method to obtain an accurate determination.

No separate measurement for payment shall be made for excavation made on borrows, quarries, temporary works or in places outside the scope of permanent works specified in the contract.

Foundation excavation for structures shall be measured in cubic metres irrespective of all classes of materials except rock encountered. The quantities to be measured shall be the net cubic content of the voids formed by the removal of the materials enclosed between the bottom of the footing and existing ground level by a surface generated by vertical lines passing through the periphery of the bottom of the footing. No payment shall be made for any excavation other than the limited excavation described above. Excavation over increased width or length, cutting of slopes, removal of slides, shoring, shuttering and planking shall be deemed as convenience for the Contractor in executing the work and shall not be measured and paid for. Backfill to be measured shall be limited to this void only with due consideration of the nature of the structure.

Foundation excavation in rock shall be deemed to be covered by the rate for rock excavation.

(3) Consumption of explosive materials, leveling, watering and compaction of original ground, construction of coffer dams, pumping out water and other ancillary and incidental works necessary to complete the item as per this specification shall not be measured for payment. They are deemed included in the measurement of the concerned item.

(4) If the excavated materials are disposed beyond 10 m length and more than 1.5 m height form the place of excavation and if filling materials are brought from beyond 10 m and/or 1.5 m below the place of filling, additional leads and lift shall be measured separately for payment. However initial lead of 10 m and lift of 1.5 m shall not be measured separately. They are deemed included in the measurement of the item itself. However, the measurement of foundation excavation shall be inclusive of all leads and lifts (i.e. no separate leads and lifts shall be measured in foundation excavation).

The measurement of leads and lifts shall be based on mass diagram of the haulage wherever applicable. All leads and lifts shall be measured as per the contract. If the material obtained from road way excavation is used fully or partially in roadway filling, the quantities for roadway excavation and roadway filling shall be computed as below.

The quantities of roadway excavation and roadway filling of the distances under reference shall be calculated separately adopting the method described as above in this Section. The computed quantity of roadway filling shall be measured in roadway filling while difference between quantities of roadway excavation and filling shall be measured in roadway excavation. The same excavated material shall not be measured both in roadway excavation and roadway filling.

918. PAYMENT

(1) Various classes of earthworks i.e. roadway excavation, roadway filling, backfilling, additional leads and lifts measured as described above shall be paid at contract unit rate of the respective item.

The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of:

(i) Arrangement of land as source of materials as much as needed.

(ii) Process Control tests.

(iii) Execution of all relevant operations described above in this Section and necessary to complete the item as per this specification.

(2) Foundation excavation for structures, measured as described above, shall be paid for at the contract unit rate for all classes of excavation. The contract unit rate for foundation excavation shall be the full and the final compensation to the Contractor as per Clause 112 and for the cost of carrying out the required operations to excavate to the lines and levels as required by the Drawing or as directed by the Engineer. No payment shall be made for the disposal of the excavated materials irrespective of all leads and lifts, preparation of foundation base, cofferdams, cribs, sheeting, shoring and bracing, foundation sealing, dewatering including pumping, removal of logs and stumps, cleaning and grubbing, diversion of flow/channel, if required and all incidentals works necessary to complete the item in accordance with this Specification.

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SECTION 1000 – SUBGRADES

SECTION 1000 – SUBGRADES

1001. SCOPE

This section deals with the treatment of the upper layers of earthworks including preparation and surface treatment of the formation, the addition of layers of selected material, the improvement of in-situ materials by addition and mixing of selected materials or by addition and mixing of lime.

1002. DEFINITIONS

(1) Formation Level

The level of the top surface of the subgrade upon which pavement structures is built up.

(2) Subgrade

Upto 300 mm below formation level is designated as “subgrade”.

(3) Capping Layers

Capping layers are layers of specified materials to be laid and compacted in the subgrade and below as required, in replacement of in-situ materials to achieve CBR conforming to Clause 609, Table 6.2.

(4) Stabiliser

The selected natural or crushed material, lime, cement and other similar materials to be mixed into the in-situ material of the subgrade is defined as the “stabilizer”.

(5) Mechanical Stabilisation

The addition and mixing of natural or crushed material to improve the in-situ material of the subgrade.

(6) Lime Stabilisation

The addition and mixing of lime of improve in-situ material of the subgrade such as in-situ material with a CBR is less than 5% or saturated soils.

(7) Treated Materials

Following the addition of stabiliser to the in-situ materials, the material is referred to as “treated material”. Treated materials may be either mechanically stabilised, lime stabilised, cement stabilised, or so on.

1003. PREPARATION AND SURFACE TREATMENTOF FORMATION

Preparation and surface treatment of formation shall be carried out only after completion off all drainage works unless otherwise agreed by the Engineer and prior to laying the subbase or the base where no subbase is required. The sequence of operations shall be as follows:

(1) Formation of Loose Untreated Materials

Materials for use in the subgrade shall not contain particles larger then 60 mm. In addition the material shall have a CBR of not less than 5% measured after a 4-day soak on a laboratory mix compacted to 95% MDD (heavy compaction), a swell of less than 1% a plasticity index of less than 40% and an organic matter content less than 3%. In-situ material in the subgrade in cutting that does not meet these requirements shall either be spoiled or, if suitable, placed in the embankment. The spoiled material shall be replaced with material meeting the requirements for loose material in the subgrade.

In fill areas, and in cutting except otherwise instructed by the Engineer, according to the material encountered, loose materials of the embankment and cuttings shall be deposited in the layers of 150 mm compacted depth. Each layer shall extend reasonably more than the full width of the embankments or cutting and shall be compacted in accordance with requirements as specified hereunder:-

(a) The material shall be broken down to the above specified grading and any oversize material which cannot be broken down to the require size shall be removed and disposed off. The material shall be scarified and the moisture content shall be adjusted by either uniformly mixing in water or drying out the material such that the moisture content during compaction is between 95% and 100% of the Optimum Moisture Content. The moisture content shall be kept within these limits until compaction is complete except where otherwise instructed by the Engineer.

(b) Each layer shall be compacted to a dry density equal to at least 95% MDD (heavy compaction).

(c) In accordance with Section 500, the Contractor shall submit to the Engineer his proposals for the compaction of the material to be used in the subgrade. The proposal shall be based on the type of plant, the range of passes and the loose depth of the layer.

The Contractor shall carry out site compaction trials, supplemented by necessary laboratory investigations, and shall satisfy the Engineer that all the specified requirements regarding compaction shall be achieved.

Site compaction trials shall be completed and approved by the Engineer before the permanent Works commences.

(d) Testing to be carried out during the construction of subgrade shall include the following:

The MDD (heavy compaction) and OMC shall be determined for each new material encountered and in every 3000m^2 or part of each layer of compacted subgrade. The field dry density shall be determined at least once per 250m^2 or part of it of each layer of compacted subgrade. The test of field density shall be conducted in staggered manner i.e. at left, at crown and at right in the carriageway.

The soaked CBR of material in the subgrade shall be determined at least in every 3000m^2 or part of it of each layer.

The Contractor shall request in writing for the Engineer's approval for each layer in accordance with Sub-clause 509 (1) and such request shall be accompanied by the tests results of the above described testing and all additional relevant information required. If the results are as specified, he will approve for addition of another layer or will ask for further tests or rework to meet the requirements.

(2) Formation of Loose Treated Materials

The sequence of operation shall be as described in Clauses 1005 to 1006 of this Specification.

(3) Formation in Rock Cutting

The subgrade in rock cutting shall be regulated after trimming the rock excavation by a regulating course of minimum 150 mm compacted depth of natural complying with the requirements of natural material for subbase as specified in Sub-clause 1201 (3).

The regulating course shall be laid, compacted and tested in accordance with Clause 1201 and the surface regularity shall meet the requirements of Clause 1101.

(4) Preparation of Formation for Rehabilitation Works

After reinforcement of any soft areas, all surface below carriageways, lay-bys, cycle tracks, footways and hard shoulders shall be well cleaned and freed from mud an slurry

(5) Proofrolling

All subgrade shall be proofrolled with a loaded scraper or truck with a minimum axle load of 8 tonnes. Proofrolling shall be satisfactorily

completed before the layer is submitted to the Engineer for approval and shall be carried out in the presence of the Engineer. All proofrolling shall be at the Contractor's expense.

(6) Surface Regularity and Tolerances

The surface regularity and tolerance of the subgrade shall meet the requirements of Clause 1101.

When each layer is completed the Contractor shall comply with the requirements of Clause510 for requesting the Engineer's approval and protecting

1004. CAPPING LAYER

Where shown on the Drawing or where in-situ material in the subgrade in cutting does not meet the requirements, in-situ materials shall be replaced with selected material from cuttings or borrow pits.

Where materials of differing quality are available for placing in the embankments, the Engineer may also instruct that certain materials should be excluded form the subgrade and that certain materials should be set part, or obtained from borrow pits for use in the upper layers.

When materials for subgrade are extracted from borrows to form the capping layers they shall be natural material complying with the following requirements:-

(1) Material classification

Materials used for use in capping layers shall be selected among soils classified as GW,GP,GC, SW in the General Classification of Soils, described in Clause 609.

(2) Material Requirements

Material for use in the capping layers shall not contain particles larger than 60 mm and their percentage passing by weight the 0.075 mm sieve shall be less than 15%. The material shall have a CBR of not less than 15% measured after a 4-day soak on a laboratory mix compacted to 95 % MDD (heavy compaction), a swell of less than 1%, a plasticity index of less than 12%.

(3) Laying and Compaction

The material shall be deposited in the layer of 150 mm compacted depth. Each layer shall extend over the full width of the embankments or cutting and shall be compacted in accordance with the requirements specified in Sub-clause 1003 (1) (a) to (d).

(4) Proofrolling and Tolerances

Proofrolling and tolerances of capping layers shall be in accordance with Sub-clause 1003 (5) and (6).

When each layer is completed the Contractor shall comply with Clause 510 for requesting the Engineer's approval and protecting the layer.

1005. MECHANICAL STABLISATION

(1) General

The extent of the mechanical stabilisation shall be detailed in the Special Specification or shown on the Drawing.

In-situ subgrade materials subject to mechanical stabilization shall be generally soils classified as SM, ML, CL, MH, CH in the General Classification of Soils described in Clause 609 with a CBR less than 5% or a moisture content close to saturation or too high moisture content to meet the compaction requirements as set out in Sub-clause 1003 (1).

(2) Material Requirement

(a) Stabiliser (Additive Material)

Additive material shall be gravel, crushed stone/gravel or sand, according to the type and characteristics of the in-situ soil as shown in the Table 10.1.

It may be crushed stone/crushed gravel, (CS) discarded material from primary crushing, or screened stone (SS) from debris and serees.

Sand may be soils classified as SP, SW in the General Classification of Soil described in Clause 610 or Sand (SSFF) obtained by screening the discarded fine fraction of primary crushing.

Gravel 12/40 shall have a percentage in weight passing the 12 mm sieve less than 20% and a percentage in weight passing the 40 mm sieve more than 85%.

Sand shall have a Sand Equivalent more than 60.

Table 10.1: Type of Additive Material

In-situ soil	Stabiliser (Additive material)	
	Gravel	**Sand**
SM	CS, SS, 12/40	-
ML	CS, SS, 12/40	-

CL	CS, SS, 12/40	-
MH		SP, SW, SSFF
CH		SP, SW, SSFF

(b) Stabilished Material Requirements

The amount of stabilizer shall be determined by the Engineer after laboratory test

The mechanically stabilized materials after mixing and compacting shall conform to the following:

- Maximum size of particles : 60 mm
- Uniformity Coefficient : min 5
- CBR at 95% MDD (heavy compaction) measured after 4 days soak : min 25%
- Swell : max. 1%

(3) Amount of Stabiliser to be added

The amount of stabilizer to be added shall be generally between 15% and 25% in weight of the in-situ material and shall be determined by the Engineer following laboratory trials, and site trials to be carried out by the Contractor in accordance with Section 500.

During the site trials, the control testing requirements shall be in accordance with Clause 507 and in addition, each set of test shall include the following:

- The MDD (heavy compaction) and OMC determined on the mixed material before compaction.

- The CBR at 95% MDD (heavy compaction) after 4 days soak.

(4) Mixing

(a) Mixing Equipment

The equipment for scarifying the in-situ material and mixing it with the stabilizer, such as scarifiers and grades, shall be capable of scarifying the materials and mixing it with the stabilizer to the full depth of the loose layer necessary to give the specified thickness of compacted material mixed and compacted in accordance with this Clause.

The equipment shall be only acceptable, if during the site trials carried out in accordance with Section 500, it produces the material to the specified requirements.

(b) Preparation of the Layer

Before the stabilizer is applied, the material to be treated shall be scarified. If required or instructed by the Engineer, oversize material shall be removed or broken down so that the maximum size of the particles is not more than specified.

(c) Spreading the Stabiliser

After the layer to be treated has been prepared, the stabilizer shall be uniformly spread over the width to be worked at the specified rate.

(d) Mixing and Watering

After the stabilizer has been spread, it shall be thoroughly and intimately mixed into the material for the full depth of the layer. Mixing shall continue until the resulting mixture forms a homogeneous tilth.

Care shall be taken both during mixing and subsequent watering operations so that the underlaying layer is not disturbed. No material from the underlaying layer is mixed with that being processed.

If watering is necessary to bring the mixture to the required moisture content, this shall be done after spreading and mixing with the stabiliser. Water shall be added in an uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed in as a separate mixing operation. Concentration of water at any point or a flow of water over the surface shall be avoided.

Any part of the mixture which becomes too wet for compaction shall be allowed to dry out until its moisture content is satisfactory for compaction.

Throughout the process of mixing the stabiliser and watering, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct uncompacted thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

(5) Compaction

(a) Thickness of Layers

The subgrade shall be constructed in the layer of 150 mm compacted depth.

(b) Compaction Requirements

The minimum density for mechanically stabilished materials shall be 95% MDD (Heavy compaction). The moisture content at the time of compaction shall be between 97% and 103% of Optimum Moisture Content.

(c) Finishing

The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material and other surface irregularities and shall be to the line and the level within the tolerances as specified in Clause 1101. If the surface fails to meet the requirements of this Specification, the Contractor shall take the action set out in the appropriate part of Section 1100 or such other action as the Engineer may instruct or agree.

(6) Construction Control Testing

(a) In-situ Material

For each new material encountered and in every 3000 m^2 or part thereof of the subgrade the following properties shall be determined:

- Grading,
- Moisture Content,
- Atterberg limits,
- The MDD (heavy compaction) and MOC,
- The CBR at 95% MDD (heavy compaction) after 4 days soak.

(b) Stabiliser

The following properties of the additive material shall be determined on opening up of a new source, in every 500 m^3 or part thereof and when in opinion of the Engineer the nature of the material is changed

- Grading,
- SE

(c) Control of Mixing

Prior to compaction in every 400 m2 or part thereof the following properties shall be determined on each new treated material used after mixing for subgrade of each layer.

- The MDD (heavy compaction) and OMC,
- The CBR at 95% MDD (heavy compaction) after 4 days soak.

(d) Control after Completion of Each Layer

The field dry density shall be determined in every 250 m^2 or part of it of each layer of compacted subgrade in staggered manner i.e. at left, at crown and at right in the carriageway.

(7) Tolerances

(a) Geometric Tolerances

As specified in Clause 1101.

(b) Amount of Stabiliser

The average amount of stabiliser, measured before mixing, over a length of 100 m, shall not be less than the amount specified.

The average amount of stabiliser, in the treated material, measured at five points over a length of 100 m, shall not be less than the amount specified.

1006. LIME STABILISATION

(1) General

The extent of lime stabilization shall be as detailed in the Special Specification or as shown on the Drawing

In-situ subgrade materials subject to lime stabilization shall be generally soils classified as ML, CL, MH, CH in the General Classification of Soil described in Clause 609, with a CBR less than 5% or a moisture content close to saturation.

(2) Material Requirements

(a) Lime

Lime shall comply with the requirements of Clause 615.

Quick like shall be used on in-situ materials which have a CBR less than 2% and which moisture content is close to saturation.

Hydrated lime shall be used on in-situ materials which have CBR between 2% and 5%.

(b) Storage and Handling

All lime shall be kept under cover and protected from moisture. Consignments shall be use in the same sequence as they received at the site. Damaged stocks or stored on the site for more than 3 months shall not be used. The Contractor shall replace them at his own cost. Operators and labour shall be provided with protective shoes, clothing, masks, gloves and goggles when they work with lime.

(c) Requirement of Lime Treated Materials

The lime treated materials after mixing and compacting shall conform to the following requirements:

▪ Maximum size of particles	:	20 mm
▪ CBR at 95% MDD (heavy compaction) measured after 4 days soak	:	min 15%
▪ Swell	:	max. 1%

(3) Amount of Lime to be added

The amount of lime to be added shall be determined by the Engineer following laboratory and site trials to be carried out by the Contractor in accordance with Section 500.

For the laboratory trials, the requirements of lime treated materials shall be as specified in Sub-clause 1006 (2) (c) except for that the CBR at 95% MDD (heavy compaction) measured on a laboratory mix after 3 days curing at ambient temperature and 4 days soak which shall not be less than 30%.

During the site trials, the control testing requirements shall be in accordance with Clause 507 and in addition, each set of test shall include the following:

- The MDD (heavy compaction) OMC determined on the mixed material before compaction,
- The CBR at 95% MDD (heavy compaction) after 3 days curing at ambient temperature and 4 days soak shall not be less than 15%.

(4) Mixing

(a) Mixing Equipment

The equipment for pulverising the in-situ material and mixing in the stabiliser shall be purpose-built equipment capable of pulverising the materials and mixing in the stabilser to the full depth of the loose layer

necessary to give the specified thickness of compacted material mixed and compacted in accordance with this Clause.

The equipment shall be only acceptable, if during the site trials carried out in accordance with Section 500, it can produce the material of the specified requirements.

The mixers shall be equipped with a device for controlling the depth of processing and mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

Mixing by grader shall not be permitted.

(b) Preparation of the Layer

Before the stabiliser is applied, the material to be treated shall be scarified and/or spread and broken down and oversize material shall be removed or broken down so that the maximum size of the particles is not more than the specified. The material shall first be pulverised to the required tilth by successive passes. Then it shall be shaped true to line, grade and cross Section and, if required, lightly compacted. The loose thickness shall be such as to give specified thickness after full compaction has been carried out.

The moisture content of the layer before addition of the stabiliser shall be adjusted to within the range of 80% to 90% of the OMC.

(c) Spreading the Stabiliser

After the layer to be treated has been prepared to the satisfaction of the Engineer, the stabiliser shall be uniformly spread at specified rate over the width to be worked at a time. If a spreader is used to spread the stabiliser ahead of the mixer, it shall be fitted with a device to ensure a uniform and controllable rate of spread both transversely and longitudinally.

Only sufficient stabiliser for immediate use shall be spread ahead of the mixing operation. If, in the opinion of the Engineer, any part becomes defective, the Contractor shall replace the material of that part as his own cost and shall rework to meet the requirements.

Only equipment actually used in the spreading or mixing operation shall be allowed to pass over the stabiliser, when so spread before it had been mixed into the material to be treated.

(d) Mixing and Watering

Immediately after the stabiliser has been spread, it shall be thoroughly and intimately mixed into the material for the full depth of the layer. Mixing shall continue until the resulting mixture forms a fine and homogeneous tilth. The mixing machine shall be set so that it cuts at least 100 mm into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

Care shall be taken during mixing and subsequent watering operations that the underlaying layer is not disturbed and that no material from the underlaying layer is mixed with that being processed.

If watering is necessary to bring the mixture to the required moisture content, then this shall be done after spreading and mixing in the stabiliser. Water shall be added in a uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed in as a separate mixing operation. Concentration of water at any point or flow of water over the surface shall be avoided.

Any part of the mixture becomes too wet after the stabiliser has been added and/or before the mixture is compacted shall be allowed to dry out until its moisture content is satisfactory. This part shall be retreated with fresh stabiliser and finished off in accordance with this Clause.

Throughout the process of mixing in the stabiliser and water, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct uncompacted thickness and shape. Any part of the mixture that becomes segregated shall be replaced by new one.

(5) Compaction and Finishing

For lime treated materials, final compaction and finishing shall be completed within 4 hours after the lime comes into contact with the material to be treated.

(a) Thickness of Layers

The subgrade shall be constructed in the layers of 150 mm compacted depth each.

(b) Compaction Requirements

The minimum density for lime treated materials shall be 97% MDD (Heavy compaction). The moisture content at the time of compaction shall be between 95% and 100% of Optimum Moisture Content.

(c) Finishing

The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material and other surface irregularities and shall be to the line and the level within the tolerances as specified in Clause 1101. If the surface fails to meet the requirements of this Specification, the Contractor shall take appropriate action to set out to comply with the requirements of the Section 1100 or agree with other action as the Engineer may instruct.

(6) Joints between New and Existing Work

The forming of construction joints and the protection of previously treated or other work shall be carried out so as to produce a uniformly compacted and homogeneous layer free from ridges or other irregularities.

Full working width, without longitudinal joints, will generally be required. Half working width may be instructed by the Engineer to pass traffic. When forming longitudinal joints at least 100 mm of the first laid half-width layer shall be retreated and mixed in with the layer of second half-width.

When forming transverse joints, at least 1.0 m length of the previously laid work shall be incorporated into the new treated layer and the Engineer may instruct that the percentage of stabiliser be increased at these places.

(7) Protection and Curing

Treated layers shall be kept continuously damp by lightly spraying with water or adhering to one of the curing systems specified below.

Treated layers shall be protected, within 8 hours of completion by one of the following methods:

(a) Completely covering the layer with clear or light coloured approved polythene sheeting of minimum thickness 0.1 mm. The sheeting shall be laid to cover the whole of the surface of the layer. At joints the sheeting shall be lapped by at least 500 mm and any damaged sheeting shall be replaced at the Contractor's expense.

The sheeting shall be securely held in contact with the layer by an approved method.

(b) Completely covering the treated material with a layer of damp uncompacted graved or soil material of minimum thickness 100 mm. The material which may form part of the next layer, shall be kept continuously damp.

Plant used for dumping and spreading material, and spraying water shall be approved by the Engineer and shall have individual axle loads not exceeding 6 tonnes.

Immediately prior to application of a curing system the surface of the treated layer shall be made thoroughly damp by lightly spraying water.

The curing system shall be kept in place and intact for a minimum of 7 days after completion of compaction. Shall areas may be temporarily removed for the purposes of carrying out control testing but only for the minimum amount of time required for the testing.

(8) Construction Control Testing/Process Control Testing

(a) In-situ Material

The following properties shall be determined for each new material encountered and in every 3000 m^2 of the subgrade or part thereof:

- Grading, Moisture Content,
- Atterberg limits,
- The MDD (heavy compaction) and OMC.
- The CBR at 95% MDD (heavy compaction) after 4 days soak.

(b) Lime

Lime shall be tested in accordance with Clause 615 for each consignment delivered at the site.

(c) Control of Mixing

The following properties shall be determined after mixing on every new treated material used for subgrade and in every 400 m^2 and part thereof of each layer of mixed material prior to compaction:

- The MDD (heavy compaction) and OMC
- The CBR at 95% MDD (heavy compaction) after 3 days curing at ambient temperature and 4 days soak which shall be not less than 15%.

(d) Control of Compaction

The field dry density shall be determined in every 250 m^2 or part of it of each layer of compacted subgrade in a staggered manner i.e. left, at crown and at right in the carriageway.

(9) Traffic

Traffic or equipment other than that actually engaged in the various treatment or protection processes, shall not run over the layer bring processed or compacted.

On compaction of curing, no traffic or equipment shall be allowed on the treated layer with the exception of that required for proofrolling, priming or construction of the subsequent layer.

(10) Tolerances

(a) Geometric Tolerances

The work shall be completed within tolerance as specified in Sub-clause 1003 (6).

(b) Amount of Stabiliser

The average amount of stabiliser, measured before mixing, over a length of 100 m, shall not be less than the amount ordered.

The average amount of stabiliser, in the treated material, measured at five points over a length of 100 m, shall not be less than the amount ordered.

The amount of stabiliser, measured at any point after mixing may vary within ±of the amount ordered.

(c) Determination of Stabiliser Content

The lime content in mixed materials shall be determined according to test 15 of BS 1924.

1007. MEASUREMENT

(1) Subgrade construction with loose untreated/treated materials, formation in rock cutting shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Engineer in the original position before the work starts and after its completion and computing the volumes of the respective work in cubic metres by average end area method.

(2) Preparation of formation for rehabilitation works shall be measured in square metre.

(3) Capping layer shall be measured in cubic metre by end area method as described in Sub-clause 1007 (1).

(4) Mechanically stabilised subgrade shall be measured in cubic metre as described in Sub-clause 1007 (1) and shall be exclusive of the measurement on the stabilizer.

Stabilisers (additive material) such as gravel, crushed stone/gravel or sand shall be measured in cubic metre as per procedure described below.

(a) Before mixing the stabiliser (i.e. gravel, crushed stone/gravel sand) quantity to be used shall be measured in stacks or in the body of transporting trucks/trippers, if it can be measured.

(b) In a length of 100 m five standard holes at the equal distances shall be dig up and materials shall be collected separately from the each hole. The average percentage of stabiliser obtained from each hole shall be worked out. Based on average percentage of stabiliser and volume treated total quantity of stabiliser used shall be computed.

Least of the quantities computed in (a) and (b) above shall be accepted for payment.

(5) The volume of lime stabilised material shall be measured in cubic metre as per end area method inclusive of lime used. The lime used shall be measured in tonne.

(6) Quick lime/Hydrated

Lime (stabiliser) shall be measured in tonne as per actual consumption.

1008. PAYMENT

The subgrade construction with loose untreated/treated materials, formation in rock cutting, additive materials and stabilizers, preparation of formation, capping layer, mechanically stabilised subgrade, and lime stabilised material shall be paid at their respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of:

(1) Arrangement of land as a source of supply of material required

(2) Compacting the ground supporting subgrade where removal and replacement of unsuitable material or loosening and recompacting is involved.

(3) Watering or drying of material in the subgrade as required.

(4) Mixing, spreading in layers brining in appropriate moisture content and compacting to the requirement of Clause 1003.

(5) Profrolling and testing.

(6) All other operations including incidental costs necessary to complete the item as per this Specification.

SECTION 1100-ROADWORKS OVERALL REQUIREMENTS

SECTION 1100-ROADWORKS OVERALL REQUIREMENTS

1101. HORIZONTAL ALIGNMENTS, SURFACE LEVELS AND SURFACE REGULARITY OF PAVEMENT COURSES

(1) Construction Control Testing/Process Control Testing

Unless otherwise directed, values given in these Specifications are minimum values for the properties of materials and the workmanship. They shall be considered satisfactory, if all results of the tests, taken at the frequencies specified, are at least equal to the values given in the relevant Section of these Specifications.

(2) Tolerances

(a) Horizontal Alignments

Horizontal alignments shall be determined from the centerline of the pavement surface as shown or calculated from the Drawing. The centerline of the pavement surfaces as constructed, and all other parallel alignments, shall be correct within a tolerance of $\pm$ 13 mm therefrom.

(b) Thickness of Pavement Layers

The average thickness of any pavement layer measured at five conjugative points at every 20 m in any Section shall not be less than the thickness specified nor more than 120% of the thickness specified or ordered by the Engineer. The thickness of the pavement layer measured at any point shall have tolerance of + 25% and -2% of the thickness specified.

(c) Surface Levels of Pavement Layers and Formation

The level measured at any point on the surface of a pavement layer to the formation level shall not deviate form the corresponding level calculated from the Drawing by more than the tolerances shown in Table 11.1.

For checking compliance with Table 11.1 measurements of surface levels shall be taken at point to be selected by the Engineer at 12.5 m centres longitudinally and at 2 m centres transversely. At junctions, the grid point spacings shall be determined by the Engineer.

(d) Surface Regularity

The surface regularity of pavement layers and the formation shall be tested at points decided by the Engineer with a rigid, steel straight-edge of 3 m length placed parallel to or at right angles to the centerline

of the road. The maximum allowable deviation of the surface below the straight-edge shall nor deviate from that shown on the Drawings by more than the tolerances shown in Table 11.1.

In addition the longitudinal slope or transverse cross fall shall not deviate from that shown on the Drawing by more than the tolerances shown on Table 11.1.

If tolerances given in Table 11.1 for level and straight edge are not in agreement, in that case the tolerances given for straight edge shall prevail.

Table 11.1: Tolerances for Level and Surface Regularity

Layer	**Level mm**	**Straight edge mm**	**Slope or Crossfall %**
Bituminous Wearing Course	± 10	6*	± 0.25
Bituminous Binder Course	± 10	6	± 0.25
Base	± 10	6	± 0.25
Subbase	± 15	10	± 0.50
Gravel Wearing Course	± 15	15	± 0.50
Formation (subgrade)	+ 0 - 25	20	± 0.50

*In case of asphalt concrete surface it shall be 4 mm.

The tolerances for level and surface regularity as given in Table 11.1 shall be applicable only for New construction, Re-construction and Rehabilitation works. These shall be not applicable in case of resealing by surface dressing/sand seal/ slurry seal in existing paved surfaces.

(e) Shoulders

Shoulders shall be constructed to the same requirements of thickness, level and surface regularity as for the adjacent pavement layers.

(f) Cuttings and Embankment Slopes

In final trimmed slope of cuttings or embankment a tolerance of +0.25 shall be permitted, i.e. if a slope of 1 in 2 is specified, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25.

(g) Width of Cutting and Embankments

The tolerance permitted in the width of the bottom of cutting shall be 200 mm between the centerline of the road and the toe of the cutting slope.

The width of embankments measured horizontally and perpendicular to the centerline of the road at the top of the embankment shall not be less than shown on the Drawing or more than that shown on the Drawing plus 50 mm.

(h) Depth of Side Drains

The difference between road level measured at the centre line of the road and that of the bottom of the side drain measured perpendicular to the centre line of the road shall not deviate form the specified in the drawing by $\pm$ 25 mm.

(3) Rectification of Earthworks and Pavement Layers Exceeding Tolerances

Where any tolerances in Sub-clause 1101 (2) are exceed, the Contractor shall assess the full extent of the area which is out of tolerances and shall make good the surface of the pavement course, earthworks or formation in the manner described below.

(a) Earthworks

Where a cutting slope is steeper, and an embankment slope is slacker than the specified slope, then the slope shall be trimmed to the specified slope. When the cutting slope is slacker, the natural ground slope above top of the cutting and the adjacent cut slopes in the both sides of the slacker slope shall be so trimmed that the entire cut slopes match together and they are environmentally stable. Where an embankment slopes is steeper than the specified slope, then the slope shall be benched and fill material shall be placed and compacted. Subsequently the slope shall be trimmed all in accordance with the requirements of Section 900.

Where the width of a cutting is less than, and the width of an embankment is more than the specified width, then the cutting or embankment shall be trimmed to the specified width. Where the width of the cutting is more than the specified width but cut slope is slacker than the specified slope, the slope shall be trimmed as described in the preceding paragraph. If the cut slope is steeper, it shall be trimmed to specified slope. The adjacent slopes shall be also trimmed to make them in harmony. Where the width, of an embankment is less than the specified width, the embankment shall be benched and filled with suitable material and compacted. The slopes shall be trimmed all in accordance with the requirements of Section 900.

Where the depth of a side drain is less than that specified, the side drain shall be excavated to the specified depth and grade. Where the depth of a side drain is more than the specified depth, the side drain shall be backfilled with suitable material compacted to a dry density of

at least 95% of MDD (Heavy compaction) up to the specified depth or the extra excavated depth shall be made good by the same material of lining of the drain as directed by the Engineer.

(b) Subgrades

Where the levels and or widths are out of tolerances, the full depth of the layer shall be reworked to the Specification. The area to be treated shall be as determined by the Engineer necessary for compliance with the Specification.

Where the results of the construction control tests are less than specified the full depth of the layer in the area representing the test shall be reworked to the Specification. However, if needed, more tests shall be conducted to ascertain the extent of the area required to be reworked.

(c) Base and Subbase

Where these consist of unbound (i.e. natural or graded stone) material the full depth of the material shall be replaced by the material complying to the specification. The area treated shall be at least 30 m long and 3 m wide or such area determined by the Engineer necessary for compliance with this Specification.

For bituminous bases the material of the full depth of the layer shall be replaced with fresh approved material laid and compacted to specification. Any area so treated shall be at least 5 m long and the full width of the paving laid in one operation.

(d) Wearing Course

The method of rectification shall be adopted depending upon the nature of the failure. Rectification shall be effected either by removing base and replacing with approved material and doing wearing course or redoing wearing course alone. The Engineer shall instruct appropriate method of rectification. The area rectified shall be the full width of the paving laid in one operation and at least 15 m long.

(4) Measurement and Payment

The Contractor shall be deemed to have allowed in his general rates and prices for the cost of complying with the requirements of Clause 1101.

Not withstanding the provisions of Sub-clauses 1101 (2) and 1101 (3) measurement and payment for earthworks and pavement works shall be made on the basis of the net-cross Section ordered by the Engineer or as shown on the Drawing. No additional payment shall be made for any variation. If the executed work is within the limit of tolerance, but is less

than the specified on drawing or ordered by the Engineer, the payment shall be made for actual quantity executed, if the executed work is more, the payment shall be made for as shown on the drawing or ordered by the Engineer.

1102. CONCRETE CHANNELLING

(1) No material in frozen condition shall be incorporated in the works, but it shall remain on site for use, if suitable when unfrozen.

(2) Laying of material containing bitumen, or mixture thereof, shall cease under the following adverse conditions:

(a) during foggy and rainy weather;

(b) when rain is imminent

(3) while the air temperature is rising, work may be performed at the temperatures of;

- 6 degree Celsius with a wind velocity of 25 km/hr
- 10 degree Celsius with a wind velocity of 55 km/hr

(4) When the air temperature is falling, works must be stopped as soon as temperature reaches 6 degree Celsius regardless of wind velocity. It shall not be resumed until the temperature is definitely rising.

(5) When strong wind is blowing and this is likely to interfere with the proper execution of the work, no surfacing, especially spraying of binder shall be done.

(6) Concrete shall not be placed during falling temperatures when the ambient falls below 7 degree Celsius or during rising temperatures when the ambient temperature is below 3 degree Celsius. The temperature of the placed concrete shall not be allowed to fall below 5 degree Celsius until the concrete has thoroughly hardened. When necessary, concrete ingredients shall be heated before mixing but cement shall not be heated.

When the ambient air temperature exceeds 40 degree Celsius during the concreting operation, the Contractor shall take measures to control the temperature of the ingredients. Such measures shall include spraying the aggregates stockpile with water to promote cooling down by evaporation and, where feasible, shading of stockpiles and the area where concreting is carried out, reducing time between mixing and placing, and restricting concreting as far as possible to early morning and late evenings. Curing

shall commence after placing of the concrete in order to prevent excessive loss of moisture.

1103. USE OF SURFACES BY CONSTRUCTION TRAFFIC

(1) The loads and intensity of construction traffic used on pavements under construction shall be regulated so that no damage is caused to sub-grade and pavement layers already constructed.

(2) The wheels and track of plant moving over various pavement courses shall be kept free of deleterious materials.

(3) Bituminous base course shall be kept clean and uncontaminated as long as it remains uncovered by a wearing course and surface treatment. Should the base course or tack/prime coat becomes contaminated, the Contractor shall make good by cleaning it to the satisfaction of the Engineer, including removal of the contaminated layer and replacing it as per the requirements of these Specifications which shall be done by the Contractor at his own risk and cost.

1104. CARE OF WORKS

The general obligations for "Care of the Works" shall inter-alia include the following:

(1) Material shall not be spread on a layer that is wet and may damage it during compaction of subsequent layer or when opened to traffic.

When material is spread out on the road, it shall, be given a good cross-fall and a light compaction on the surface with a steel-tyre roller, in order to facilitate run-off during rainy weather.

(2) All completed works in a layer shall be protected and maintained until the subsequent layer is placed. Maintenance shall include immediate repairs to any damage or defects, which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in a good condition.

(3) Before priming any completed layer or placing a subsequent layer thereon, any damage to the existing layer shall be repaired so that after repair or reconstruction if necessary, it shall conform in all respects to the requirements specified for that layer. All repair work other than repairs of minor surface damages shall be inspected and tested before covering up.

The previously constructed layer shall also be thoroughly cleaned of all foreign material before construction of a succeeding layer. In the case of bituminous work, the existing layer shall be thoroughly broomed and all dung, clay, mud and other deleterious and loose material shall be removed.

Where necessary, the surface shall be sprayed with water before, during and after brooming to remove all foreign material.

Roads shall not be made dirty as a result of construction of works, transportation of equipments, plants, labour and/or materials. In the case of becoming dirty, they shall be cleaned immediately.

1105. MEASUREMENT AND PAYMENT

No measurement and payment shall be made for the works required under this Clause. All costs in connection with the requirements specified herein shall be deemed included in the rates and prices of the related items of works in the Bill of Quantities.

SECTION 1200 – SUBBASE, BASE, HARD SHOULDER AND GRAVEL WEARING COURSE

SECTION 1200 – SUBBASE, BASE, HARD SHOULDER AND GRAVEL WEARING COURSE

1201. MECHANICALLY STABLE SUBBASE

(1) Scope

This Clause covers the construction of subbase with naturally occurring mechanically stable quartzitic gravel, river gravels and transported gravels, or materials resulting from the weathering of rocks, or clayey/silty sand.

(2) Sources of Materials

Subbase materials shall be obtained from approved sources in borrow or cut or from such other sources of supply as may be specified or approved from time to time for use.

The Contractor shall comply with all requirements of Section 800 in respect of borrow pits.

(3) Material Requirements

The subbase material after placing and compaction shall conform to the following requirements:

(a) Gravel

The grading of the material after placing and compaction shall be a smooth curve within and approximately parallel to the envelope given in Table 12.1.

The Plasticity Index shall not exceed 6.

Table 12.1: Grading Envelope for Gravel

Sieve Size (mm)	Percentage passing by weight
63.0	100
40.0	70-100
20.0	50-85
10.0	40-75
4.75	30-60
2.36	20-45
1.18	15-35
0.075	4-15

(b) Sands, Silty and Clayey Sands

- % passing 2 mm sieve : max 95%
- % passing 0.075 mm sieve : min 10 – max 30%
- Plasticity Index : min 5 – max 12%
- Plasticity Modules : max 300%

(PI_ % passing 0.425 mm sieve)

(c) All Materials

The CBR of the material, after 4 days soaking, shall not be less than 30% at 95% MDD (Heavy Compaction).

(4) Compaction Trials

Before commencing construction and from time to time as may be considered necessary by the Engineer, the Contractor shall carry out compaction trials in the presence of Engineer on each main types of materials to be compacted in the Works. He shall carry out all necessary laboratory and field testing and supply the Engineer with the copies of the results of all tests.

Following completion of the compaction trials, the Contractor shall submit to the Engineer, for his approval, proposals for the compaction of each main type of material. The Contractor's Proposals shall include reference to the type of equipment, the operating weights and tyre pressures and the method of adjusting moisture content.

If, in the opinion of the Engineer, the results of the compaction trials indicate that the Contractor's proposed plant and methods shall achieve the densities specified, the Engineer shall approve the same. Otherwise the Contractor shall submit in writing proposals for modifying the plant and/or methods and shall compact further trials in accordance with these modified proposals until the Engineer approves the Contractor's proposals.

(5) Laying and Compacting

The material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown on the Drawing or instructed by the Engineer. Every reasonable effort shall be made to prevent segregation during mixing, dumping, spreading, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm and when a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum layer thickness shall be 100 mm.

The material shall be down to the grading specified in Sub-clause 1201 (3). Any oversize material which connot be broken down to the required size shall be removed and disposed off.

The material shall be scarified and the moisture content adjusted by either uniformly mixing with water or drying out the material such that the moisture content during compaction is between 95% and 100% of the Optimum Moisture Content (IS 2720 Part 8). It shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out, but once 25% of the compactive effort has been applied no further trimming or correction of surface irregularities shall be allowed.

All rolling shall be longitudinal and shall commence at the outer edges of the pavement and progress towards the centre, except that on super elevated curves, rolling shall progress from the lower to the higher edge. Where laying is carried out in lanes care must be taken to prevent water entrapment.

The final trim shall be in cut and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works. Following the final trim the material shall be compacted to a dry density of at least 95% of MDD (IS 2720 Part 8). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out. If so, the Contractor need to apply fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

On completion of compaction, the surface shall be well closed, free from movement under compaction plant and free from compaction planes, ridges, cracks, loose or segregated material. If the surface fails to meet the specified requirements, the Contractor shall take the action set out in the appropriate part of Section 1100 or such other action as directed by Enginner.

(6) Proofrolling

Unless otherwise directed by the Engineer, the Contractor shall proofroll the completed layer with a steel three wheeled roller applying a load of not less than 5 tonnes per metre width of roll and the layer shall be free from visible movement under the proofroller. Approval of the layer shall only be given after the satisfactory completion of the proofrolling and any remedial measures shall be at the Contractor’s expense.

(7) Setting out and Tolerances

The layer shall be set out and constructed to the appropriate tolerance specified in Section 1100.

(8) Drainage of Subgrade and Subbase

The subgrade and subbase shall be kept continuously drained and any damage caused by water accumulating on or running off the surface shall be made good at the Contractor's expense.

Water accumulated on any part of the subgrade or subbase, shall be removed and disposed off. Any material which becomes saturated, or cannot then be compacted to the required density, shall be replaced as specified at Contractor's own expense.

(9) Testing

(a) Process Control

The minimum testing frequency for the purpose of process control shall be as given in Table 12.2

Table 12.2: Minimum Testing Frequency

Tests	One test in every	Min. no of tests per section
Materials:		
Gradation	200m^3 or part of it and change in source	2
Plasticity Index	200m^3 or part of it and change in source	2
Maximum Dry Density and Optimum Moisture Content	200m^3 or part of it and change in source	2
Field Density and Moisture Content	500 m^2	2
Construction Tolerance:		
Surface Levels	10 m	-
Thickness	25 m	-
width	200 m	-

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Engineer to test the quality of materials and workmanship for compliance with the requirements of this section.

Any materials or workmanship that do not comply with the specified requirements shall be replaced with materials and/or workmanship complying with the specified requirements or be replaced to comply with the specified requirements.

(10) Measurement

Mechanically stable subbase shall be measured in cubic metre by taking cross Section at intervals of 10 metres or as directed by the Engineer in the

original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

(11) Payment

The subbase construction shall be at their respective contract unit rate. In addition to stated in Clause 112, the contract unit rate shall be also full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Sections 500, 800 and Clause 1201.

1202. GRADED CRUSHED STONE BASE AND SUBBASE

(1) Scope and Definition

This clause covers procuring, furnishing and placing of approved crushed stone on top of the complete subgrade or subbase and constructing a crushed stone subbase or base, as the case may be, in accordance with the requirement of this Specification.

"Graded crushed stone" shall mean crushed stone with a smooth grading curve within a specified envelope.

The class of the stone of the graded crushed stone to be provided shall be specified in the Special Specification or in the Bill of Quantities.

(2) Sources of Materials

The Contractor shall be responsible for locating and developing suitable of material for graded crushed stone. Such sources shall be termed quarries. The opening up of quarries, and the construction and maintenance of access roads shall be carried out in accordance with Section 800.

(3) Material Requirements

The material shall comply with following requirements:

(a) It shall consist of crushed stone, free from clay, organic or other deleterious matter.

(b) It shall comply with the physical requirements defined in Table 12.3.

Table 12.3: Physical Requirements of Graded Crushed Stone

Tests	Base		Subbase
	B*	C1*	D1*
LAA Max. %	30	35	40
AIV Max. %	20	25	30
SSS Max. %	12	12	12
FI %	25	25	30
CBR Min. %	80	80	60
CR Min. %	100	80	30
PI Max.	NP	NP	6

*** B, C1 and D1 are classes of materials**

(c) It shall comply with the Following Gradings

After processing, placing and compaction in the pavement the grading of the material shall be smooth curve within and approximately parallel to one of the envelopes defined in Table 12.4.

Table 12.4 Grading Envelopes for Graded Crushed Stone

Sieve Size (mm)	Percentage passing by weight		
	Base	Subbase	
		SB1*	SB2*
63.0	-	100	100
40.0	100	75-100	85-100
31.5	85-100	42-75	75-95
20.0	62-92	25-60	60-87
10.0	40-70	15-45	50-80
4.75	26-55	12-37	12-32
2.36	21-53	6-25	7-21
0.60	12-28	5-21	6-17
0.075	2-10	3-12	3-10

*** SB1 and SB2 are classes of subbase**

(4) Crushing, Screening and Mixing

Unless otherwise instructed, crushing shall be carried out at least in two stages.

The crushing, screening and proportioning of materials and their subsequent mixing shall be carried out using methods and machines acceptable to the

Engineer. To avoid segregation, graded crushed stone shall be moistened when being handled and shall not be stockpiled in heaps higher than 5 m.

If the Contractor wishes to add material from another source in order to achieve the specified grading the following conditions shall apply:

(a) The Contractor shall be responsible for all costs associated with the provision and mixing in of the material, including land acquisition.

(b) The material shall be non-plastic, hard and durable as specified. Particles shall be free from organic materials, clay and other deleterious substances.

(c) Only material passing the 6.3 mm sieve may be added, the percentage to be added shall be agreed with the Engineer and in any case shall not exceed 15% by weight of the mixture.

(d) The minimum crushing rations as well as other physical requirements as specified in Sun-clause 1202 (3) shall be maintained.

(5) Transporting Graded Crushed Stone

Graded crushed stone shall be transported and dumped in such a way that no segregation occurs.

(6) Compaction Trials

The Contractor shall carry out compaction trials in accordance with Sub-clause 1201 (4).

(7) Laying and Compacting

The Contractor shall take appropriate measures to prevent segregation during dumping and spreading operations.

The graded crushed stone shall be laid by plant capable of distributing the graded crushed stone in a layer of uniform thickness and without segregation.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm, and where a greater thickness is required, the graded crushed stone shall be laid in two or more equal layers.

The compacted thickness of any base layer shall not be less than 3 times the maximum size of the graded crushed stone and the compacted thickness of any subbase layer shall not be less than 2 times the maximum size of the graded crushed stone.

As soon as possible after laying, compaction shall be carried out. The moisture content shall be adjusted as necessary and, during compaction, care shall be taken to maintain the moisture content evenly at the specified value. Unless otherwise instructed by the Engineer, the moisture content at the time of compaction shall be between 95 and 100% of the Optimum Moisture Content determined as per IS 2720 Part 8. The appropriate Sections of Sub-clause 1201 (5) shall also be applicable for this Clause 1202.

All rolling shall be longitudinal and shall commence at the outer edges of the pavement and progress towards the centre, except that on superelevated curves, rolling shall progress from the lower to the higher edge. Where laying is carried out in lanes care must be taken to prevent water entrapment.

The minimum dry densities to be achieved as a percentage of the Maximum Dry Density (MDD) determined in accordance with IS 2720 Part 8 shall be:

Base	:	98% of MDD
Subbase	:	95% of MDD

On completion of the compaction the surface shall be well closed, mechanically stable, free from visible movement under compaction plant and free from compaction planes, ridges, cracks, loose or segregated material. If the surface fails to meet the requirements of these Specifications, the Contractor shall take the action set out in the appropriate part of Section 1100 or such other action as directed by the Engineer.

(8) Proofrolling

The Contractor shall proofroll completed layers in accordance with Sub-clause 1201 (6).

(9) Setting out and Tolerances

Graded crushed stone subbase and base shall be set out and constructed to the tolerances given in Section 1100.

(10) Testing

(a) Process Control

The minimum testing frequency for process control shall be as specified in Table 12.5.

Table 12.5: Minimum Test Frequency

Tests	One test in every	Min. no of tests per section
Materials:		
Gradation	200m^3 or part of it and change in source	2
Plasticity Index	200m^3 or part of it and change in source	2
Flakiness Index	200m^3 or part of it and change in source	2
Maximum Dry Density and Optimum Moisture Content	100m^3 or part of it and change in source	2
Los Angeles Abrasion	200m^3 or part of it and change in source	-
Aggregate Impact Value	200m^3 or part of it and change in source	-
Sodium Sulphate Soundness	500m^3 or part of it and change in source	-
Crushing Raito	200m^3 or part of it and change in source	-
CBR	500m^3 or part of it and change in source	-
Field Density and Moisture Content	500 m^2	2
Construction Tolerance:		
Surface Levels	10 m	-
Thickness	25 m	-
Width	200 m	-
smoothness	40 m^2	-

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Engineer to test the quality of materials and workmanship for compliance with the requirements of this section.

Any materials or workmanship that do not comply with the specified requirements shall be replaced by materials and/or workmanship complying with the specified requirements, or be repaired so that after being repaired it shall comply with the specified requirements.

(11) Measurement

Graded crushed stone base and subbase shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Engineer in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

(12) Payment

The graded crushed stone construction shall be paid at their respective contract unit rate. In addition to stated in Clause 112, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Section 500, 800 and Clause 1201.

1203. WATER BOUND MACADAM BASE AND SUB-BASE

(1) Scope

This work shall consist of clean, crushed aggregates mechanically interlocked by rolling and bonded together with screening binding material and water laid on a properly prepared subgrade/subbase/base or existing pavement, as the case may be and finished in accordance with the requirements of this specification and in close conformity with the lines, grades, cross Sections and thickness as per approved plans or as directed by the Engineer.

(2) Sources of Materials

The Contractor shall be responsible for locating and developing suitable sources of material for water bound macadam. Such sources shall be termed quarries or borrows. The opening up of quarries/borrows and the construction and maintenance of access roads shall be carried out in accordance with Section 800.

(3) Material Requirements

(a) Coarse Aggregates

Coarse aggregates shall be either crushed or broken stone, crushed slag. The aggregates shall conform to the physical requirements set forth in Table 12.6.

Table 12.6: Physical Requirements of Coarse Aggregates

Tests	Base	Subbase
	D1*	E1*
LAA Max. %	40	45
ACV Max. %	30	30
FI Max. %	30	30

* D1 and E1 are classes of materials

The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated, dirt and other deleterious material.

After processing, placing and compaction in the place the grading of the material shall be a smooth curve within and approximately parallel to one of the envelopes defined in Table 12.7.

Table 12.7: Grading Envelope of Coarse Aggregates

Sieve Size (mm)	Percentage passing by weight	
	Grading 1	Grading 2
75.0	100	-
63.0	90-100	100
50.0	35-70	90-100
40.0	0-15	35-70
25.0	-	0-15
20.0	0-5	-
12.5	-	0-5

(b) Screening

Screening to fill voids in the coarse aggregate shall generally consist of the same material as of the coarse aggregate. However, where permitted predominantly non-plastic material like crushed rock fines or natural angular pit sand may be used for this purpose.

Screening shall conform to the grading set forth in Table 12.8

Table 12.8: Grading Requirements for Screenings

Sieve Size (mm)	Percent passing by Weight
9.50	100
4.75	85-100
0.09	10-30

(4) Compaction Trials

The Contractor shall carry out trials in accordance with Sub-clause 1201 (4).

(5) Construction Operations

(a) Preparation of Base

The surface of the sub-grade/sub-base/base to receive the water bound macadam course shall be prepared to the specified lines and crossfall and made free of dust and other extraneous material. any ruts or soft yielding places shall be corrected in an approved manner and rolled if necessary by sprinkling water until firm surface in obtained.

As far as possible, laying water bound macadam course over an existing thick, bituminous layer may be avoided since it shall cause problems of internal drainage of the pavement at the interface of two

courses. It is desirable to completely pick out the existing thin bituminous wearing course where water bound macadam is proposed to be laid over it. However, in exceptional cases, where the intensity of rain is low and the interface drainage facility is efficient, water bound macadam can be laid over the existing thin bituminous surface by cutting 50 mm x 50 mm furrows at an angle of 45 degrees to the centre line of the pavement at one metre intervals in the existing road. The directions and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base coarse beneath the existing thin bituminous surface.

(b) Inverted Choke

If water bound macadam is to be directly over the sub-grade, without any other intervening pavement course, a 25 mm thick screenings or coarse sand shall be spread on the prepared subgrade before application of the coarse aggregates is taken up.

(c) Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly and evenly upon the prepared subgrade/subbase/base to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than twice the maximum size of the aggregate. Whenever possible, approved mechanical devices shall be used spread the aggregates uniformly so as to minimise the need for manual rectification afterwards. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any approved means so as to achieve the specified results.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case the aggregates shall be dumped in heaps directly on the surface prepared to receive the aggregate nor hauling over uncompacted or partially compacted base shall b e permitted. No segregation of coarse or fine aggregates shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots shall be removing or adding aggregate as required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved plan.

(d) Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 8 to 10 tonne

capacity or tandem or vibratory rollers of approved type. The type of roller to be used shall be approved by the Engineer based on trial run.

Except on superelevated portions where the rolling shall proceed from inner edge to the outer rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centerline of the road, in successive passes uniformly lapping preceding tracks by at least one half width of wheel of the roller.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or subbase course.

The rolled surface shall be checked transversely and longitudinally, with templates and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired crossfall and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which have been crushed excessively during compaction or have become segregated shall be replaced with aggregates of the same or better quality.

(e) Application of Screenings

After the coarse aggregate has been rolled as above screenings shall be applied gradually over the surface to completely fill the interstices. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screening shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes of ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller

on the coarse aggregate. These operations shall continue until no more screening can be forced into the voids of the coarse aggregate.

The spreading, rolling, and brooming of screening shall be carried out in only such lengths of the road which could be completed within one day's operation.

(f) Sprinkling of Water and Grouting

After the screening have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth an a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

The minimum dry densities to be achieved as a percentage of the specific gravity shall be:

Base	:	82% of the specific gravity
Subbase	:	80% of the specific gravity

(g) Setting and Drying

After the final compaction of water bound macadam course the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

The compacted water bound macadam course shall be allowed to completely dry and set before the next pavement course is laid over it.

(6) Proofrolling

The Contractor shall proofroll compacted layers in accordance with Sub-clause 1201 (6).

(7) Setting out and Tolerances

Water bound macadam base and subbase shall be set out and constructed within the tolerances given in Section 1100.

(8) Testing

(a) Process Control

The minimum testing frequency for process control shall be given in Table 12.9

Table 12.9: Minimum Testing Frequency

Tests	One test in every	Min. no of tests per section
Materials:		
Gradation	200m^3 or part of it and change in source	2
Flakiness Index	200m^3 or part of it and change in source	2
Los Angeles Abrasion	200m^3 or part of it and change in source	-
Aggregate Impact Value	200m^3 or part of it and change in source	-
Field Density	500 m^2	2
Construction Tolerance:		
Surface Levels	10 m	-
Thickness	25 m	-
Width	200 m	-
smoothness	40 m^2	-

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Engineer to test the quality of materials and workmanship for compliance with the requirements of this section.

Any materials or workmanship that do not comply with the specified requirements shall be replaced by materials and workmanship complying with the specified requirements, or be repaired so that after being repaired it shall comply with the specified requirements.

(9) Measurement

Water bound macadam subbase/base shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Enginner in the original position before the work starts and after its completion and computing the volumes in cubic metres by average and area method.

(10) Payment

Water bound macadam subbase/base shall be paid at their respective contract unit rate. In addition to stated in clause 112, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Sections 500, 800 and Clause 1201.

1204. SHOULDER

(1) Definition

The term “shoulder” means the part of the road falling between the edge of the pavement and the side ditch or embankment slopes above the formation level.

(2) Material for Construction of Shoulders

Material for construction of shoulders shall be as shown on the Drawing or instructed by the Engineer. It may consist of and include:

(a) Gravel wearing course or natural material in accordance with Clauses 1205 and 1201.

(b) Graded crushed stones in accordance with Clause 1202

(c) A single bituminous surface treatment (SBST) in accordance with Clause 1303.

(d) A sand surfacing in accordance with Clause 1305.

(3) Construction of Shoulders

Shoulder shall be constructed concurrently with construction of the adjacent pavement layers and with the same materials, except in case the base course is bituminous mix, the “upper shoulder” shall be constructed subsequent to the base course. Shoulders shall not be constructed ahead of adjacent pavement layers and the Contractor shall ensure that the method of construction is such that at no time water gets prevented form draining off the pavement layers. The method of laying and compacting shoulder material and the compaction requirements shall be in accordance with the relevant Sub-clauses of 1201, 1202 and 1205.

(4) Setting out and Tolerances

Shoulders shall be set out and constructed to the tolerances given in Section 1100.

(5) Surface Treatment of Shoulders

Surface treatment of shoulders shall be as shown on the Drawing or instructed by the Engineer. Material for Bituminous surface treatment shall be in accordance with Sub-clause 1204 (2) and the method of construction shall be in accordance with the relevant Clause of Section 1300.

Where topsoil and grassing is shown on the Drawing or instructed by the Engineer, 50 mm of humus or topsoil shall be spread on the completed shoulder and lightly rolled. Grass seeds shall be planted in accordance with the relevant Clauses of Section 2800 and kept watered until growth is established. Top soiling and grassing shall be in accordance with relevant Clause of Section 2800.

(6) Measurement and Payment

Where shoulders are constructed with the same material as the adjacent pavement layers no separate items shall be included in the Bill of Quantities for shoulder construction and the measurement and payment shall be in accordance with the relevant Clause of Section 1200.

Where shoulder construction differs from that of adjacent pavement layers the method of measurement and payment shall be in accordance with the relevant Clause relating to the type of material shown on the Drawing or instructed by the Engineer for shoulder construction.

Bituminous surfacing shall be measured and paid in accordance with relevant Clause of Section 1300. Top soiling and grassing shall be measured and paid in accordance with relevant Clauses of Section 200 and 2800.

1205. GRAVEL WEARING COURSE

(1) General

(a) Definitions

The term “gravel” used throughout in this Clause means any material used as a wearing course, and shall include crushed rock, natural or crushed gravel, decomposed rock and clayey sands.

A “gravel wearing course” means a top surfacing course constructed from one or a combination of the materials stated above and may be a course placed on the formation of a new road where final pavement surface is not included in the Contract, or placed on the formation of a service, diversion or access road.

(b) Sources of Material

Material for gravel wearing course may be obtained from any of the sources described hereunder:

(i) Borrow pits, alluvial deposits, etc.
(ii) Spoil areas
(iii) Excavation in cutting widened if necessary

In all cases the Engineer shall instruct the Contractor about the source of material to be used and the location where the material will be placed.

(c) Inspection of Site

Where a source of material is available for inspection during the Tender Period the Contractor shall satisfy himself as to the nature and amount of work involved particularly in respect of the volume of overburden, the suitability of material in work, the degree of selection necessary, the method of extraction, and access to the source.

(d) Borrow pits, Alluvial Deposits, etc. and Spoil Areas

The Contractor shall comply with all the requirements of Section 800 in respect of borrow pits, alluvial deposits, etc. and spoil areas.

(2) Classification of Material

Material for gravel wearing course shall be classified as RF2, SC, GC for natural materials as per the definition given in Clause 609 or crushed stones.

The material may require the use of either a grid or sheepsfoot roller with more than 8 ton mass per metre width of roll to break it down and/or screening to achieve the specified grading.

(3) Material Requirements

The grading of the gravel after placing and compaction shall be a smooth curve within and approximately parallel to the grading envelope given in the Table 12.10.

Table 12.10: Grading Envelope of Wearing Course Material

Sieve Size (mm)	Percentage passing by weight	
	Class 1	**class 2**
37.5	-	100
25.0	100	85-100
20.0	95-100	85-100
14.0	80-100	65-100
10.0	65-100	55-100
4.75	45-85	35-92
2.0	30-68	23-77
1.0	25-56	18-62
0.425	18-44	14-50
0.075	12-32	10-40

The material shall have a minimum CBR of 30% after 4 days soaking at 95% MDD (heavy compaction) and plasticity index between 15 and 35..

Materials of the respective class namely D1, C2, E1 or E2 whichever may be applicable shall conform to its requirements specified in Table 6.3 of Section 600.

(4) Sequence of Works

Unless otherwise instructed by the Engineer, the Contractor shall commence laying wearing course starting as close as possible to the source and shall work away from it so that the maximum amount of compaction is given the wearing course by the Contractor's vehicles. The Contractor shall route/regulate his vehicles to give even wear and compaction over the whole width of the wearing course.

(5) Preparation of Formation

For new road construction, the formation shall be prepared in accordance with Section 1000.

For existing roads the minimum requirements for preparation of the formation area as follows:

The formation shall be cleaned of all foreign matter and loose materials. Any potholes, ruts, corrugations, depressions and other defects which have appeared due to improper drainage, traffic or any other cause shall be corrected. If considered necessary by the Engineer, the Contractor shall scarify, water, grade and recompact the subgrade to line and level all at his own expense. The Engineer may require the formation to be proofrolled by a loaded truck, scraper or other approved means prior to dumping of the wearing course material. The cost of all such proofrolling shall be at the Contractor's expense.

(6) Setting Out

The gravel wearing course shall be set out to the tolerances given in Section 1100.

(7) Laying and compacting

The gravel wearing course material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown in the Drawing or instructed by the Engineer. Every reasonable effort shall be made to prevent segregation during the loading, hauling, dumping, spreading, mixing, trimming and compacting operations.

The compacted thickness of any layer laid, processed and compacted at one time shall not exceed 150 mm and where a greater compacted thickness is required, the material shall be laid and processed in two or more equal layers.

The material shall be broken down in the pavement to the grading specified in Sub-clause 1205 (3). Any oversize material which connot be broken down to the required size shall be removed and disposed off by the Contractor.

The material shall be scarified and the moisture content adjusted by either uniformly mixing with water or drying out the material such that the moisture content during compaction is between 95% and 102% of the Optimum Moisture Content determined as per IS 2720 Part 8. It shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out but once 25% of the compactive effort has been applied no further trimming or correction of surface irregularities shall be allowed.

The final trim shall be in cut and the Contractor shall ensure that material form the trim is neither deposited in low areas nor spread across the section but graded clear of the works.

Following the final trim the material shall be compacted to a dry density of at least 95% MDD (Heavy compaction). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out by applying fog sprays of water or other approved means sufficient to maintain the surface and/or material within the specified limits of moisture content.

Vibratory rollers for the final compaction shall not be allowed.

(8) Proofrolling

The Contractor shall proofroll the completed layers in accordance with Subbase 1201 (6).

(9) Tolerances

The gravel wearing course shall be constructed to the tolerances specified in Section 1100.

(10) Testing

(a) Process Control

The minimum testing frequency for process control shall be as given in 12.11.

Table 12.11: Minimum Testing Frequency

Tests	One test in every	Min. no of tests per section
Materials:		
Gradation	$300m^3$ or part of it and change in source	-
Plasticity Index	$300m^3$ or part of it and change in source	-
CBR	$300m^3$ or part of it and change in source	-
LAA	$300m^3$ or part of it and change in source	-
AIV	$300m^3$ or part of it and change in source	
Maximum Dry Density and Optimum moisture content	$400m^3$ or part of it and change in source	-
Field Density & moisture content	$200\ m^2$	3
Construction Tolerance:		
Surface Levels	10 m	-
Thickness	25 m	-
Width	200 m	-
smoothness	$40\ m^2$	-

(b) Routine Inspection and Testing

Routine inspection and testing will be carried out by the Engineer to test the quality of materials and workmanship for compliance with he requirements of this Section.

Any material or workmanship that do not comply with the specified requirements shall be replaced with materials and/or workmanship complying with the specified requirements or be repaired so that after being repaired it shall be comply with the specified requirements.

(11) Maintenance

The wearing surface shall be maintained by the Contractor in its finished condition and shall be watered graded, dragged, reshaped, or recompacted as necessary, until the certificate of Completion is issued, or until the Engineer instructs that the road shall be opened to public traffic, whichever is sooner.

(12) Measurement

Gravel wearing course shall be measured in cubic metre by taking cross Section at intervals of 10 metres or as directed by the Engineer in the original position the work starts and after its completion and computing the volumes in cubic metres by average and area method.

(13) Payment

Gravel wearing course shall be paid at their respective contract unit rate. In addition to stated in clause 112, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Section 500, 800 and Clause 1201.

1206. TELFORD BASE (BLOCK PITCHING)

(1) Block pitching shall consist of clean hard durable single size stones of size equivalent to the thickness of the base course, but not less than 150 mm nor more than 300 mm in their longest dimension.

(2) A layer of sand or quarry dust shall first be laid over the base to a thickness of 75 mm. The block pitching shall then be laid with the longest dimension of each stone in the vertical direction and breaking joint with adjoining stones. The highest points of protruding stones shall then be broken off with a knapping hammer and the interstices filled with spalls. The whole shall then be rolled with a smooth wheeled roller of not less than 8 tonnes capacity. Spalls shall be continuously added to the interstices during rolling until the whole remains immovable under the roller and has a uniform surface without high or low spots.

(3) Measurement

Telford base shall be measured in cubic metre by taking cross Sections at intervals of 10 metres or as directed by the Engineer in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

(4) Payment

The Telford base construction shall be paid at their respective contract unit rates. In addition to stated in Clause 112, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Section 500, 800 and Clause 1201.

1207. DRY BOUND MACADAM BASE AND SUB-BASE

(1) Scope

This work shall consist of clean, crushed or broken aggregates mechanically interlocked by compacting rolling and bonded together with screening binding material in dry condition and laid on a properly prepared subgrade/subbase/base or existing pavement, as the case may be and finished in accordance with the requirements of this specification and in close

conformity with the lines, grades, cross Sections and thickness as per approved plans or as directed by the Engineer.

(2) Source of Material

The Contractor shall be responsible for locating and developing suitable sources of material for dry bound macadam. Such sources shall be termed quarries or borrows. The opening up of quarries/borrow and the construction and maintenance of access roads shall be carried out in accordance with Section 800.

(3) Materials Requirements

(a) Coarse Aggregates

Coarse aggregate shall conform to the requirements of Clause 1203 (3) (a).

(b) Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as of the coarse aggregate. However, where permitted predominantly non-plastic material like crushed rock fines or natural angular pit sand may be used for this purpose.

Screenings shall conform to the gradings set forth in Table 12.12

Table 12.12: Grading Requirements for Screenings

Sieve Size (mm)	Percent passing by Weight
9.50	100
4.75	95-100
2.80	65-95
0.71	30-65
0.30	15-30
0.075	0-15

(4) Compaction Trials

The Contractor shall carry out trials in accordance with Sub-Clause 1201 (4).

(5) Construction Operations

(a) Preparation of Base

The surface of the sub-grade/sub-base/base to receive the dry bound macadam course shall be prepared to the specified lines and crossfall and made free of dust and other extraneous material. any ruts or soft yielding places shall be corrected in an approved manner and rolled if necessary until firm surface is obtained.

As far as possible, laying dry bound macadam course over an existing thick, bituminous layer may be avoided since it shall cause problems of internal drainage of the pavement at the interface of the two courses. It is desirable to completely pick out the existing thin bituminous wearing course where dry bound macadam is proposed to be laid over it. However, in exceptional cases, where the intensity of rain is low and the interface drainage facility is efficient, dry bound macadam can be laid over the existing thin bituminous surface by cutting 50 mm x 50 mm furrows at an angle of 45 degrees to the centre line of the pavement at one metre intervals in the existing road. The directions and depth of furrows shall be such that they provide adequate bondage and also serve to drain water to the existing granular base coarse beneath the existing thin bituminous surface.

(b) Inverted Choke

If dry bound macadam is to be laid directly over the sub-grade, without any other intervening pavement course, a 25 mm thick screenings or coarse sand shall be spread on the prepared subgrade before application of the coarse aggregate is taken up.

(c) Spreading Coarse Aggregates

The coarse aggregate shall be spread uniformly and evenly upon the prepared subgrade/subbase/base to proper profile by using templates placed across the road about 6 m apart, in such quantities that the thickness of each compacted layer is not more than twice the maximum size of the aggregate. Wherever possible, approved mechanical devices shall be used to spread the aggregates uniformly so as to minimize the need for manual rectification afterwards. Aggregates placed at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any approved means so as to achieve the specified results.

The spreading shall be done from stockpiles along the side of the roadway or directly form vehicles. In no cases the aggregates shall be dumped in heaps directly on the surface prepared to receive the aggregates nor hauling over uncompacted or partially compacted base shall be permitted. No segregation of coarse or fine aggregate shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The surface of the aggregate spread shall be carefully checked with templates and all high or low spots shall be remedied by removing or adding aggregates as required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface as per approved plan.

(d) Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or tandem or vibratory rollers of approved type. The type of roller to be used shall be approved by the Engineer based on trial run.

Except on superelevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the centerline of the road, in successive passess uniformly lapping preceding tracks by at least one half width of wheel of the roller.

Rolling shall be discontinued when the aggregate are partially compacted with sufficient void space in them to permit application of screening. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or subbase course.

The rolled surface shall be checked transversely and longitudinally, with and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired crossfall and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which have been crushed excessively during compaction or have become segregated shall be replaced with aggregates of the same or better quality.

(e) Application of Screenings

After the coarse aggregate has been rolled as above screenings shall be applied gradually over the surface to completely fill the interstices. These shall not be damp or wet at the time of application. Dry rolling with vibratory roller shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or by mechanical spreaders, or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes of ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the

coarse aggregate. These operation shall continue until no more screenings can be forced into voids of the coarse aggregate.

The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operations.

The minimum dry densities of the dry bound macadam to be achieved as a percentage of the specific gravity shall be:

Base	:	82% of the specific gravity
Subbase	:	80% of the specific gravity

(6) Proofrolling

The Contractor shall proofroll compacted layers in accordance with Sub-clause 1201 (6).

(7) Setting out and Tolerances

Dry bound macadam base and subbase shall be set out and constructed within the tolerances given in Section 1100.

(8) Testing

(a) Process Control

The minimum testing frequency for process control shall be as given in Table 12.9.

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Engineer to test the quality of materials and workmanship for compliance with the requirements of this section.

Any materials or workmanship that do not comply with the specified requirements shall be replaced by materials and workmanship complying with the specified requirements, or be repaired so that after being repaired it shall comply with the specified requirements.

(9) Measurement

Dry bound macadam subbase/base shall be measured in cubic metre by taking cross Section at intervals of 10 metres or as directed by the Engineer in the original position before the work starts and after its completion and computing the volumes in cubic metres by average end area method.

(10) Payment

Dry bound macadam construction shall be paid at their respective contract unit rate. In addition to stated in clause 112, the contract unit rate shall be also the full and the final compensation for cost of making arrangement for traffic control and other costs required to complete the work complying with the requirement of Section 500, 800 and Clause 1201.

SECTION 1300 – BITUMINOUS SURFACE AND BASE COURSE

SECTION 1300 – BITUMINOUS SURFACE AND BASE COURSE

1301. GENERAL REQUIREMENTS FOR PRIME COAT, TACK COAT, SURFACE DRESSING, PENETRATION MACADAM, SAND SEAL AND SLURRY SEAL

(1) Scope

This Clause comprises general requirements for bituminous binder, aggregate and trial sections common to Clause from 1302 to 1306.

(2) Bituminous Binder

All bituminous binders shall comply with the relevant requirements set out in Section 600.

(3) Storage and Handling of Bituminous Binder

When carried in bulk containers, of binder temperature during and at the time of storage shall be kept in a manner acceptable to the Engineer. During storage the temperature of the bituminous binder shall be kept as low as possible, consistent with reasonable pumpability. Any bituminous binder not conforming to the requirements of Sub-clause 1301 (4) shall be rejected by the Engineer as unsuitable for use.

When bitumen emulsion are stored on site in large container, then the conditions of storing shall comply with the manufacture's instructions and/or as per BS 434 (1) – 1984 (1997).

Where bitumen emulsions are stored on site in drums, the drums shall be regularly "rolled" to ensure mixing of the contents. Prior to using, all bituminous emulsion drums shall be "rolled" just before opening and use. Emulsions shall be protected against frost and temperatures below 3^{o} C.

The bitumen storage area and heating station shall be cleared of vegetation, kept neat and tidy. The drums shall be stacked on their sides in small quantities with gaps between each stack to reduce fire risk.

Bitumen distributors and boilers shall be kept clean at all times. When changing the grade of bitumen and at the end of each day's work, all boilers and distributors shall be thoroughly cleaned out with a solvent. The flushings from boilers and distributors shall not be poured any where indiscriminately, but shall be led by drainage channels to disposal pits. Care shall be taken that flushings do not find their way into storm water ditches or streams. All boilers, pre-heating pits, tools and plant shall be kept scrupulously clean.

When filling the bitumen distributor from the boilers or bulk containers, the bitumen shall be passed through a filter of fine wire mesh having opening of not more than 0.6 mm.

On completion of the works, the disposal pit and drainage channels shall be filled in and topsoiled. The site shall be left clean and tidy.

(4) Heating of Bituminous Binder

The bituminous binder shall be heated in boilers or bulk storage containers, equipped with adequate pumps and accurate thermometers. No bitumen shall be heated in a boiler when the thermometer is broken, inaccurate or not equipped with it.

The minimum pumping temperatures, the range of spraying temperatures and the maximum heating temperatures of cut-backs, penetration grade bitumens and emulsions are given in Table 13.1 below.

Table 13.1: Temperatures Ranges for Heating and Spraying Binders

Binder	Temperatures (^{o}C)			
	Minimum Pumping	Spraying *		Maximum Heating
		Slot-jets	Atomizing jets	
Cut-back RC 800	60	110-115	-	120
Cut-back RC 3000	80	125-135	-	135
Cut-back MC 30	10	35-45	50-60	65
Cut-back MC 70	25	55-65	70-85	85
Cut-back MC 800	60	100-115	120-135	135
Cut-back MC 3000	80	125-135	135-150	150
Bitumen 180/200	105	155-165	160-170	170
Bitumen 180/100	115	160-170	160-170	170
Emulsion ** K1-60	-	-	-	95
Emulsion ** A1-60	-	-	-	95

* *These spraying temperatures are for guidance only, since the optimum spraying temperature depends on the temperature/viscosity relationship of the bitumen.*

** *The minimum pumping and spraying temperatures for K1-60/A1-60 shall be in accordance with the manufacturer's recommendations.*

For slot-jets the viscosity for spraying shall be 70 to 100 centistokes and for atomizing jets 35 to 60 centistokes.

No penetration grade bitumen, cut-back bitumen, or emulsion shall be heated above the maximum temperature given in the Table. Any overheated bitumen or emulsion shall be removed from the site and disposed off by the Contractor.

The rates of application of binder specified or instructed by the Engineer refer to volumes of binder corrected to 15.6^{o}C using Standard Petroleum Measurement Table (ASTM D 1250).

(5) Weather Limitations

The minimum surface temperatures for spraying of the different types and grades of binder shall be :

80/100 penetration grade bitumen:	50^{o} C
MC-3000 cutback bitumen:	22^{o} C
MC-800 cutback bitumen:	15^{o} C
MC-30 cutback bitumen:	10^{o} C
Emulsions:	5^{o} C

When a cold wind is blowing the above temperatures shall be increased by 5^{o} C

No bituminous work shall be done during foggy or rainy weather. Strong wind may interfere with the proper execution of the work. Therefore, no surfacing, especially spraying of binder, shall be done when strong wind is blowing.

Bituminous material, except for bitumen emulsions and certain types of prime coat if instructed by the Engineer, shall not be applied on a damp surface.

(6) Cutting Back of Bitumen

The maximum amounts of paraffin as given in Table 13.2 may be added with the permission of the Engineer to the basic 80/100 penetration grade bitumen upon the road surface temperature at the time of spraying. Lesser amounts than those indicated may be used, if the site conditions allow the development of sufficient adhesion between binder, aggregate and existing surface. Diesel or kerosene shall be used for cutting back of bitumen as per the direction of the Engineer.

Table 13.2: Maximum Addition of Paraffin

Range of Road Surface Temperature ^{o} C	Maximum Addition of Paraffin by Volume %	Range (approximate) of Corresponding Ambient Air Temperature ^{o} C
22-29	7	10-16
22-36	5	16-21
39-43	3	21-26
43-50	1	26-31
above 50	NIL	above 31

The temperature of bitumen, when paraffin is introduced, shall not be higher than 120^{o} C. The paraffin shall be sucked from 200 litre drums in measured quantities through the bitumen pump and circulated with the bitumen for a minimum of 45 minutes. During this process all burners shall be shut off and no open flames allowed near the distributor.

(7) Adhesion Agent

Where required the adhesion agent shall be of an approved type and shall be used in accordance with the manufacturer's instructions and as instructed by the Engineer.

(8) Safety Precautions

The Contractor shall take every precaution to avoid fire or health hazards. He shall always ensure that:

(a) bitumen is heated only to the temperature required for the particular application;

(b) hot bitumen never comes in contact with water;

(c) suitable protective clothings, foot wears and gloves are used when handling bitumen; and

(d) dust is reduced to the minimum.

Care is required when using rapid-curing cut-back, because of the highly flammable nature of the solvent.

(9) Trial Sections

The Contractor shall carry out trial sections at location instructed by the Engineer to demonstrate to the Engineer that this his surfacing operation is capable of executing the works in accordance with the Specification.

Prior to the commencement of trials the Contractor shall submit in writing to the Engineer his proposals for applying binders and aggregate. On receipt of the Engineer's approval, the Contractor shall proceed with the trials, but in absence of such approvals the Contractor shall submit fresh proposals to the Engineer.

In the course of such trials the Engineer may call upon the Contractor to modify his method of working, to employ other items of equipment and to amend the rates of spread at which various materials are applied.

When the Engineer is satisfied that the Contractor is capable of constructing surfacing that complies with the Specification after trial Section or Section, the Contractor shall receive permission to commence the work. No

variation in the approved procedures shall be made without the Engineer's prior consent in writing.

None of the foregoing provisions prevent the Engineer from requiring the Contractor to vary his materials, equipment or methods of working at any time during the execution of Works, if he considers this to be essential for execution of the works in accordance with this Specification.

(10) Measurement and Payment

No separate measurement and payment shall be made for complying with the requirements of Sub-clause from 1301 (1) to 1301 (9). The Contractor shall include related costs of complying with the requirements of Clause 1301 in his rates of the items covered in Clauses from 1302 to 1306.

1302. QUALITY OF MATERIAL

(1) Scope and Definitions

This Clause covers the application of a bitumen prime and tack coat to be applied on a prepared pavement layer.

A prime coat means a thin layer of low viscosity bituminous binder applied to an absorbent non-bituminous surface. If the prime coat is to be trafficked, it shall be covered with binding material.

A tack coat means a thin layer of bituminous binder applied to a bituminious surface.

(2) Materials

The prime coat shall consists of cut back bitumen MC30/MC70 complying with Section 600 from a source approved by the Engineer. The grade and the rate of application of cutback to be used shall be instructed by the Engineer on site after field trials.

However, the nominal rate of application of the prime coat shall be around 1 lit per sq.m. If the prime coat is to be applied in more than one lane, allowance shall be made for overlapping of lanes by 150 mm. Tentative temperature of application shall be around 50^{o}-70^{o} C .

For tack coat, the binder shall be a penetration grade bitumen applied hot immediately prior to laying the bituminous mixture or alternatively a rapid curing cutback RC-800 or medium curing cutback MC30, MC70 or MC-800 applied at sufficient time before laying the bituminous mixture to allow the evaporation of the cutter (solvent); or a quick-breaking emulsion K1-60 applied sufficiently before laying the bituminous mixture to allow the

emulsion to break and the water to evaporate and run off. The binder shall comply with Section 600.

Blinding material shall consist of fine aggregate, or sand, or crusher dust as required and shall contain not more than 15 percent retained on a 6.3 mm sieve. The blinding material, if required by the Engineer, shall be specified in the Special Specification.

(3) Preparation of Surface.

The surface to be sprayed shall be thoroughly cleaned by sweeping with mechanical brooms and/or washing or other approved means. All laitance of soil or binder material, loose and foreign material shall be removed.

All loose material shall be swept clear of the layer to expose the full width of the layer upon which prime/tack coat shall be applied. The surface to be sprayed shall be checked for line, camber and level, and the surface corrected, made good as necessary and approved by the Engineer before any bituminous spray is applied. The Engineer's approval, or otherwise, of the surface shall be given immediately prior to the Contractor's intention to start spraying.

Unless otherwise directed by the Engineer, immediately prior to the application of prime coat, the surface of the layer shall be sprayed with water to dampen the surface, but in no case the surface shall be made saturated. If the water is over applied, the surface shall be allowed to dry until dampness is uniform over the entire surface.

In order to bring the surface to be primed to the condition required, water shall be applied in small increments by a distributor. Any water on the surface after spraying shall be allowed to drain away before the prime coat is applied.

No traffic shall be allowed on the prepared surface

(4) Spraying of Prime Coat and Tack Coat

Soon after the surface to be sprayed has been prepared as specified in Sub-clause 1302 (3) and approved by the Engineer, the edges of the area shall be marked out with a line of string or wire pegged down at intervals not exceeding 15 m on straights or 7.5 m on curves. The prime or tack coat shall be sprayed on to it at the specified rate. Spraying shall be carried out not later than 12 hours after the surface has been prepared.

The quantity of binder used shall give complete coverage of the surface with a slight trace of run-off in places. Shall the specified rate of spray appear to be incorrect, the Contractor shall immediately stop spraying, inform the Engineer and amend the spray rate as instructed by the Engineer.

The temperature for storage and spraying shall be as given in the Table 13.3.

Table 13.3: Temperature for Storage

Type of Prime	Maximum storage temperature ^{o}C	
	Up to 24 hrs.	Over 24 hrs.
Cutback bitumens		
MC-30	65	40
MC-70	80	50

Bitumen shall be sprayed from a pressure distributor complying with the requirements of Sub-clause 1303 (6) and no spraying shall be permitted except in small areas, or to make good a defective area caused by a blocked nozzle.

The nozzle shall be arranged to give a uniform spray and shall be tested prior to spraying by discharging on to suitable material (such as building paper, metal sheets, etc.,) or into special troughs made for this purpose. Testing shall not take place on the road, and any bitumen spilt on the ground shall be cleaned off.

If during spraying, a nozzle becomes blocked or develops a defect, the spraying shall be made good with a hand spray, and the machine repaired before further spraying is commenced.

When commencing and stopping spraying, sheets of building paper or metal at least 2 m wide shall be spread across the full width to be spread across the full width to be sprayed to give a clean sharp edge.

The metal sheets used for stopping and starting work shall be cleaned after each run and the troughs used for testing shall be cleaned at the end of each day's work.

During spraying all kerbs, road furniture, culvert headwalls, tree boles and the like which are liable to be disfigured by splashing of bitumen shall be protected, and any such feature which is accidentally marred by bitumen shall be cleaned off with a suitable solvent or made good.

(5) Curing and Blinding of Prime Coat

If after application of the prime coat, the bituminous material fails to penetrate within the time specified of if the road must be used by traffic, blinding material shall be spread in the amount required to absorb any excess bituminous material and to protect the primed surface.

Blinding material shall be spread from trucks in such a manner that no wheel shall travel on uncovered bituminous material.

Unless the Engineer permits otherwise, all loose material on the sprayed surface, including any blinding material, shall be removed before any further layer of the pavement is laid.

(6) Tolerances

The actual rate of application of bituminous binder across the width of each spray run shall not vary by more than ± 5% pf the rate ordered and the actual of application of binder for each single run of the spray shall not vary from this specified rate by more than 0.03 litre per square metre.

(7) Testing

Tray tests shall be taken at least twice a day during priming operation to check calculations based on dipping of spray trucks.

The minimum testing frequency for the purpose of process control shall be as given in the Table 13.4.

Table 13.4: Minimum Testing Frequencies

Test	Minimum number of tests
Quality of binder	The Contractor shall produce certificates from concemed suppliers to the effect that all materials supplied by them comply with the relevant Specifications. In addition, one set of tests for each 50,000 litres of supply of binder
Binder temperature for application	At regular close intervals
Rate of application of binder	Two tests per run

(8) Measurement

Binding material shall be measured in litre. For computation of the quantity following methods shall be adopted.

(a) Designed/instructed rate of application times specified area sprayed, computed in litres corrected to 15.6^{o} C.

(b) Actual rate of application measured through tray tests times specified area sprayed, computed in litres corrected to 15.6^{o} C.

(c) Actual consumption in the specified area sprayed measured in litres corrected to 16.6^{o} C by dip stick reading of the distributor.

The lowest value of the above three methods shall be adopted for payment. However, if the rate of actual spray of binder is much less or more than the designed/instructed rate of spray so appropriate rectification which the contractor shall execute at his own cost.

Emulsion/bitumen and cutter shall be measured on the basis of their percentage actually used in the work.

(9) Payment

Emulsion/bitumen and cutter shall be paid at the respective contract unit rate which shall be the full and the final compensation for compliance of all requirements specified in Clause 1301 and 1302 in addition to those specified in Clause 112.

1303. SURFACE DRESSING

(1) Scope and Definitions

This clause covers the application of one or more coats of surface dressing, each coat consisting of a layer of bituminous binder sprayed on a based prepared previously, followed by a cover of stone chipping properly rolled to form a wearing course to the requirements of these Specifications.

A single surface dressing means an application of bituminous binder to the road surface followed immediately by a singly layer of uniform sized chippings.

A multiple surface dressing means two or more surface dressing placed one on the other.

(2) Materials

(a) Binder

The binder shall be a suitable cationic quick-breaking emulsion such as K1-60 or K1-70 from a source approved by the Engineer with the bitumen content of not less than 60 and viscosity (Degrees Engler at 20^{o} C) between 6 and 20 or a medium-curing cut-back MC 3000 or MC-800 or a penetration grade 80/100 bitumen.

The type of binder shall be specified in the Special Specification or in the Bill of Quantities.

(b) Chippings

(i) Hardness, Soundness, Shape and Cleanliness

The chippings shall consist of crushed stone or natural screened gravel, apparently cubical in shape and free from visible stone dust and harmful material such as clay, salt, organic matter or other deleterious substances. The percentage passing the 0.075 sieve shall not exceed 0.5% by weight.
The chipping shall comply with the requirements specified in Table 13.5, for the appropriate class as specified in the Special Specification or in the Bill of Quantities.

Table 13.5: Physical Requirements of Chippings

Chipping	*HP	A	B	C1	C2
LAA max.	20	25	30	35	35
AIV max.	20	20	20	20	20
SSS max.	12	12	12	12	12
CR max.	100	100	100	80	-
FI max.	20	20	20	25	-
Degradability	<5	<5	<5	<5	<5

* means high performance aggregate.

The minimum size of the stone to be crushed to produce the chipping shall be at least 4 times the maximum size of the chippings.

(ii) Grading

The grading requirements of chipping shall be as specified in the Table 13.6.

Table 13.6: Grading Requirements of Chippings

Sieve Size (mm)	Percentage passing by weight			
	Nominal Sizes			
	14/20	10/14	6/10	4/6
25.00	-	-	-	-
20.00	85-100	100	-	-
14.00	0-20	80-100	100	-
10.00	0-3	0-15	80-100	100
6.30	-	0-3	0-15	85-100
4.75	-	-	0-10	-
2.80	-	-	0-2	0-10
1.18	0-2	0-2	-	-
0.60	-	-	-	0-2
0.075	0-0.5	0-0.5	0-0.5	0-0.5

The Engineer shall reject the chipping not conforming to be the above requirements.

(3) Rate of Application of Binder

The rate of spray of binder and the size and rate of spread of chippings shall be as specified in the Special Specification, BOQ or as instructed by the Engineer.

Tray tests shall be carried out at least twice per run during surface dressing operations to check spray and spread rates calculated from spray truck chippings and chip-spreader coverage, and more frequently when a number of short lengths are being surface dressed. Spray truck dippings and chip-spreader coverage shall be checked for each length sprayed.

(4) Crushing, Screening, Washing and Stockpiling Chippings.

The construction plant provide and the methods of operating it, shall be such as to produce chippings which shall meet the specified requirements of Sub-clause 1303 (2) (b). This may require washing the chippings to meet the cleanliness requirements.

The Contractor shall comply with Section 800 when chipping are stockpiled. If required, the stockpiles area shall be surfaced with 100 mm thickness of gravel or other material, acceptable to the Engineer. Any contaminated chippings shall not be used in the Works. After use the stockpile area shall be cleared, topsoiled and left neat and tidy.

(5) Precoated Chippings

The bituminous binder used for precoated chipping shall be a medium curing cut-back MC-30 or a semi-stable or stable emulsion such as anionic A2 or A3 cationic K2 or K3 unless otherwise instructed by the Engineer. The amount of bitumen binder used to precoat chipping shall be specified in the Special Specification or shall be as instructed by the Engineer.

Precoating shall be carriedout in a mixing machine acceptable to the Engineer. The precoated chipping shall not be tacky and liable to agglomerate. The chipping precoated with cut-back or emulsion shall be stockpiled for the lapse of time required by the solvents or water to evaporate.

The precoated chipping shall be kept free of contamination by dust or other deleterious matter.

(6) Construction Plant for Pavement Works

(a) Bitumen Distributors

Bitumen distributors shall be truck mounted and shall have sufficient power to maintain uniform speeds for the proper application of the binder. The truck shall be equipped with an accurate tachometer showing the driver the speed in metres per minute. The truck shall be fitted with a gauge bar and chain or any other acceptable device clearly visible to the driver to enable him to follow the required edge. The distributor tank shall have a capacity of at least 4,000 litres and shall be fitted with a device for indicating the quantity in the tank at any time. It shall be equipped with heaters capable of maintaining temperatures up to 200^{o} C and be fitted with an accurate thermometer.

The circulation system shall permit pumping around the tank and around the spray bar without actually spraying. Spray bars shall be available for spraying in widths varying from 0.5 m to 4 m and shall be adjustable transversely so that the operator can follow the required edge independently. The spray nozzles shall be arranged to give a uniform spray and the shut-off shall be quick-acting with an antidrip device. The pressure in the spray bar shall be sufficient to give a good distribution and spraying of the binder.

Distributors shall be capable of applying bituminous binder within the limits of $\pm$ 5% of the specified rate of application over any portion of the surface.

Distributors shall be checked and calibrated before starting any work or when required by the Engineer. This shall include the calibration of all the metering devices and checking the uniformity of the transverse distribution of spray. All distributors shall be furnished with a “rate fo spray/machine speed” chard.

(b) Chip-spreaders

Mechanical chip-spreaders shall be capable of spreading the chippings uniformly over variable widths, from 0.5 to 3.5 m, at the rates specified.

The number and output of chip-spreaders shall be sufficient to ensure that chipping are spread immediately after the bituminous binder has been applied.

Chip-spreaders shall be checked and calibrated before starting any work or when required by the Engineer.

(c) Rollers

The main rolling shall be carried out with self-propelled pneumatic tyred rollers, having a wheel-load of more than 2 tonnes. The tyres shall be smooth and their pressure shall be more than 0.4 N/mm2.

Where approved by the Engineer steel-wheeled rollers shall be used in tandem with pneumatic tyred rollers after all excess chippings have been removed and insufficiently chipped areas have been chipped over. Only steel-wheeled rollers weighing less than 8 tonnes (total weight) shall be accepted.

The number and output of rollers shall be sufficient to ensure that rolling does not lag behind spreading. To the extent possible, two pneumatic tyred rollers shall be used for each chip-spreader.

(d) Miscellaneous Equipment

Sufficient trucks and loading machinery shall be employed to ensure an adequate, prompt and continuous supply of chippings.

Rubber tyred mechanical rotary brooms towed by or mounted on rubber tyred vehicles shall be provided. Tractor toed air compressor with sufficient length of hose pipes and air jet nozzle shall be provided to ensure sufficient cleaning of surface to be sprayed with bituminous layers.

(7) Preparation of Surface

Immediately before spraying, all loose material and foreign matter shall be removed by thorough brushing with mechanical brooms and/or washing or by use of compressors or by other methods acceptable to the Engineer. All hardened mud or other foreign matter shall be loosened by scraping before sweeping. The debris shall be deposited well clear of the surface to be sprayed. Road furniture (manholes covers etc.) shall be covered with adhesive paper or similar materials. Kerbstones, roadside, and any other objects what shall not benefit from binder spray shall be protected in a manner approved by the Engineer.

Any defect of the surface shall be made good as instructed by the Engineer and no binder shall be sprayed until the surface has been approved by the Engineer. The Engineer’s approval or otherwise of the surface shall be given immediately prior to the Contractor’s intention to start spraying.

(8) Application of Surface Dressing

Soon after the surface has been prepared and approved, the quantity of binder, chippings, requirement of equipment and other resources shall be

worked out so that any operation is not delayed due to lack of required material or resources.

The binder shall be uniformly sprayed at the specified rate. Spraying of the binder shall be in accordance with the requirements specified in Sun-Clause 1301 (4). Spraying shall not be carried out later than 12 hours after the surface has been prepared.

Building paper of sufficient width (not less than 600 mm) or other approved protective material shall be used at the start and finish of each spray run to enable the distributor to reach its calibrated road speed. Each spray jet shall be kept open before discharging binder onto the pavement under treatment.

Ends of previous surface treatment run shall be trimmed back to make the traverse edge straight and to clean it. This shall form the start point of the subsequent spray run. The spray run shall be limited to 300 m of length unless the Contractor demonstrates his ability to plan and execute longer length without impairing quantity of work. Spray width shall be calculated allowing for 150 mm longitudinal overlap with adjoining spray passes and for the width that the following chipping spreader is able to cover. Longitudinal sprayed butt joint shall not be permitted. The Contractor shall submit his spray width and length proposals to the Engineer for approval.

The spraying width shall normally be of one lane width so that construction traffic may run over the other lane.

Immediately after the binder has been sprayed, clean and dry chippings shall be uniformly applied at the specified rate by the use of mechanical chip-spreaders. The elapsed time between the spraying of binder spreading of chippings shall in no case exceed one minute.

Shall it become apparent that the supply of chipping is about to fail, the binder spraying shall be immediately stopped and shall not resume until and adequate supply of chipping is assured.

The correct rate of spread is generally assessed visually, as providing complete coverage, with the film of binder still visible between the chippings. Shall the coverage appear to be incorrect, the Contractor shall immediately inform the Engineer, who shall amend the rate of spread accordingly. Any excess of chipping shall be removed by hand and any insufficiently chipped area shall be chipped over by hand, so that adequate coverage is obtained. Brooming of the material to effect redistribution of chippings shall not be permitted.

Rolling shall begin immediately after the chippings have spread and, in no case, later than two minutes after the application of binder.

Rolling shall continue until all chippings are firmly embedded into the binder and until all excess chipping have been removed or insufficiently

chipped areas have been chipped over. The number of passes shall be agreed with the Engineer. Usually, each point shall receive at least 6 passes of the pneumatic tyred roller.

Excessive rolling, resulting in the crushing of chipping, shall be avoided. The roller speed shall not exceed 8 km/h, unless otherwise directed by the Engineer. Additional rolling on a previously completed section shall be given later in the heat of the day by pneumatic tyred rollers in tandem with steel three wheeled rollers unless otherwise instructed by the Engineer.

(9) Aftercare and Control of Traffic

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the stones being whipped off.

The Contractor shall erect temporary traffic restriction signs, barriers and removable bumps or any other device, as instructed by the Engineer, to prevent vehicles traveling too fast over the newly laid surface dressing. Vehicle speed shall be restricted to a maximum of 30 km/h, until there is sufficient adhesion to ensure that the chippings shall not be dislodged by faster vehicles.

Where possible, the traffic shall be distributed across the road so as to obtain uniform polishing of the road surface.

After traffic has been permitted to run on the surface dressing for a period of at least two weeks and when instructed by the Engineer, all loose chippings shall be swept and taken away. Windrows of loose chipping shall not be allowed to accumulate at the sides of the road.

(10) Rectification of Defects

If any defect in surface dressing work is found, the reasons of the defect shall be established and keeping them in view the defect shall be rectified as per direction of the Engineer. It required, the Engineer shall ask the contractor for redoing the defective portion.

The Contractor shall rectify or redo the defective work at his own expense.

(11) Tolerance

The final average overall width of the surface dressing measured at six equidistant points over a length of 100 m shall be at least equal to the width specified or instructed. Al no point shall the distance between the centerline of the road and the edge of the surface dressing be narrower than that instructed by more than 13 mm.

The actual rate of application of binder across the lane width shall not by more than ± 5% of the rate ordered and for each single run of the spray it shall not vary from the specified rate by more than 0.03 lit per square metre.

The actual rate of application of chipping along and across the lane width for each single run of the chip-spreader shall not vary by more than ± 5% of the rate ordered.

(12) Testing

(a) Process Control

The minimum testing frequency required for the process control shall be as given in the Table 13.7

Table 13.7: Minimum Testing Frequency

Test	Minimum number of tests
MATERIALS:	
AGGREGATE:	
Grading	One test every 50 m^3 or part of it and in every change of source
Flakiness Index (FI)	One test every 50 m^3 or part of it and in every change of source
Los Angeles (LAA)	One test every 250 m^3 or part of it and in every change of source
Aggregate Impact Value (AIV)	One test every 250 m^3 or part of it and in every change of source
Crushing Ratio (CR)	One test every 250 m^3 or part of it and in every change of source
Degradability Test	One test every 500 m^3 or part of it and in every change of source
Sodium Sulphate Soundness	One test every 500 m^3 or part of it and in every change of source
Stripping Value	Initially one set of 3 specimens for each source of supply subsequently when warranted by change in the quality of aggregates
Rate of Application	Two tests per run
BITUMINOUS BINDERS:	
Quality of Binder	***The Contractor shall produce certificates from the concemed all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each 50,000 litres or part of it of supply
Binder Temperature for Application	At close intervals
Rate of Application of Binder	Two tests per run
CONSTRUCTION TOLERANCES:	
Width	One test each and every spray run
Smoothness	All apparently rough areas to be checked.

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out to test the materials and workmanship for compliance with the requirements specified in this Section.

Any materials or workmanship not complying with the requirements specified, shall be replaced or redone with the materials or workmanship complying with the Specifications or, be repaired so as to comply with the requirements specified.

(13) Measurement

Binding material (emulsion/bitumen and cutter) shall be measured separately in litre. For computation of the quantity the following methods shall be adopted.

(a) Design/instructed rate of application times specified area sprayed computed in litres corrected to 15.6^{o} C.

(b) Actual rate of application measured through tray tests times specified area sprayed, computed inlitres corrected to 15.6^{o} C.

(c) Actual consumption in specified area sprayed measured in litres corrected to 15.6^{o} C by dip stick feading of the distribution.

The lowest value of the above three methods shall be adopted for payment. However, if the rate of actual spray of binder is much less or more than the designed/ instructed rate of spray so as to impair quality of surface dressing, the Engineer shall reject the work or shall ask for appropriate rectification which the contractor shall execute at his own cost.

Bitumen and cutter shall be computed on the basis of percentage actually used in the work.

Chipping of each nominal size shall be measured in tonne. For computation of quantity the following methods shall be adopted.

(a) Design/instructed rate of application of chippings times specified area applied, computed in tonne.

(b) Actual rate of application of chippings times specified area of application computed in tonne.

The lower of these two values shall be adopted for payment. However rate of application shall not vary with designed/instructed rate of application to impair quality of surface dressing. In such event the Engineer shall reject the work or ask the Contractor to rectify at his own cost.

Measurement of precoated chippings shall be as stipulated in the contract.

(14) Payment

The binder i.e. emulsion/bitumen and the cutter shall be paid as per their respective contract unit rate. The Contractor shall be the full and the final

compensation for the cost of preparation of surface to receive binder, heating, mixing with cutter, spraying, rectification wherever required, compliance of all provisions specified in Clause 1301 and 1303 in addition to those specified in Clause 112.

Chipping of each nominal size as specified shall be paid at their respective contract unit rate. The Contract unit rate shall be full and the final compensation for the cost of compliance of all provisions specified in Clauses 1301 and 1303.

The pre-coated chipping shall be stipulated in the contract.

1304. PENETRATION MACADA, SEMI-GROUT

(1) Scope.

This work shall consist of compacted crushed coarse aggregates with application of bituminous binder and choke aggregate in accordance with the requirements of these Specifications. Reference shall be made to Clause 1301, as provisions contained therein shall be in this Clause also.

(2) Materials

(a) Aggregate

The aggregate shall consist of crushed rock or crushed gravel. They shall be of angular shape and of such character that it shall compact and interlock under rolling. It shall be of reasonably uniform quality throughout and free from clay, earth, dust or other deleterious matter. It shall comply with the following requirements:

Los Angeles Abrasion (LAA)	- Max. 40%
Aggregate Impact Value (AIV)	- Max. 30%
Sodium Sulphate Soundness (SSS)	- Max. 12%

The grading of coarse and choke aggregate shall be within the limits specified in the Table 13.8.

Table 13.8: Grading of Aggregate for Penetration Macadam

Sieve Size (mm)	Percentage passing by weight			
	Coarse aggregate (Course 75 mm thick)	Coarse aggregate (Course 75 mm thick)	Key Aggregate (type I)	Key Aggregate (typeII)
75.00	100	-	-	-
63.00	90-100	100	-	-
50.00	20-55	90-100	-	-

37.50	0-15	40-75	-	-
25.00	-	15-35	-	-
20.00	0-15	0-15	100	100
12.50		0-5	90-100	90-100
10.00 4.76 2.36 1.18			40-70 0-15 0-5	40-75 5-25 0-10 0-5

When the emulsion is used in place of bitumen the aggregate shall be of the composition as specified in the Table 13.9.

Table 13.9: Composition of Aggregate

Compacted thickness of layer	Nominal single sized aggregate	Percentage
50 mm	40 mm 28 mm 14-20 mm	60% 30% 10%
65 mm – 75 mm	50 mm 40 mm 14-20 mm	60% 30% 10%

(b) Binder

The binder shall be straight run bitumen of 80/100 penetration, or cut-back bitumen of RC-3000 grade or emulsion of class A1-60, A1-55, K1-60 or K1-70 as specified in the Special Specification or in the Bill of Quantities.

(3) Rate of Application of Binder and Aggregates

Unless otherwise specified the rate of spray of binder and aggregate shall be as given in the Tables 13.10 and 13.11.

Table 13.10: Rate of Application of Binder and Rate of Spread of Aggregate per sq.m

Compacted thickness	Binder	Coarse Aggregate	Key Aggregate
75 mm	6.8 litres	0.09 m^3	0.018 m^3
50 mm	5.0 litres	0.06 m^3	0.015 m^3

When emulsion is used, rate of application of emulsion shall be as specified in the Table 13.11.

Table 13.11: Rate of Application of Emulsion

Thickness of layer (mm)	Rate of application I/m^2
50	3.0-5.5 (4.0)*
65	4.0-7.0 (5.5)*
75	5.5-8.0 (6.5)*

* Rate given in the bracket is the nominal rate of application.

(4) Preparation of Existing Surface

The surface containing holes or depressions shall be repaired by removal of all loose materials and replacement with a suitable patching mixture or other material approved by the Engineer. This shall be compacted to produce a tight surface conforming with the adjacent areas. Bumps and waves which impair the riding qualities of the surface, shall be removed and required cross slope and grade shall be provided by scarification and re-compaction or by other such means as shall be agreed or ordered by the Engineer. The base shall then be swept clean of all loose and foreign materials.

For use of emulsion clean sand or quarry fines shall normally be laid upon the prepared based to a depth not exceeding 13 mm.

(5) Application of Coarse Aggregate

Immediately following preparation of the base (if this is not practicable the base must be re-cleaned of loose and foreign material) coarse aggregate shall be spread in loose depth so as to provide the specified thickness of surface course with required cross slope and grade after compaction. The aggregate shall be spread by hand or by an approved spreading device. Dumping in mass on the base shall not be permitted. The shallers at the edge of the surface course shall be prepared in advance of spreading the aggregate to allow the roller to roll the shaller edge and the edge of the loose aggregate simultaneously. Precautions shall be taken to prevent the coarse aggregate form becoming mixed or coated with earth or other deleterious matter both before and after spreading. The surface of the loose aggregate shall be carefully shaped and all high and low spots shall be remedied by removing or adding aggregate. The coarse aggregate shall then be dry rolled with a three wheel roller weighing not less than 8.00 tonnes. Rolling shall start longitudinally at he sides and proceed towards the centre of the pavement overlapping on successive passes by at least one half the width of the rear wheel. The compacted coarse aggregate shall then be tested with a straight-edge and camber template to ensure that it has a firm, even surface true to cross-section and having a texture which shall allow uniform penetration of the binder.

The aggregate shall be spread to the required contour and to such a thickness that, after being compacted its minimum thickness shall not be less than specified.

In case of hand spreading, each load of aggregate shall be unloaded outside the area upon which it is to be spread, and precaution shall be taken prevent the aggregate becoming contaminated with dust or foreign matter during the whole of the operations. The spreading shall be carried out with shovels and not with forks, care being taken to avoid segregation of the different sizes of aggregate. In case of mechanical spreading, the aggregate shall be spread by mechanical means such as a spreader box.

Where emulsion is used instead of bitumen, the aggregate of various sizes shall be thoroughly mixed and shaped before compaction. Alternatively, 14 mm to 20 mm materials may be spread over the larger material after the later has been placed in position and vibrated into the interstices. The minimum quantity of water shall be applied during rolling to bring up a slurry evenly in the aggregate within such a depth of the surface of the road as may be specified. It is preferable that the lower or slurried layer, which is thus waterbound, shall not exceed two thirds of the total thickness of the compacted thickness of the aggregate.

(6) Application of Binder

Binder shall be applied to the rolled coarse aggregate by means of an approved binder distributor complying with the requirements of Sub-clause 1303 (6) or such other means as the Engineer shall approve. The quantity of binder to be applied shall be as specified in Tables 13.10 and 13.11 and it shall be applied at the temperatures specified in Sub-clause 1301 (4). At the time of applying straight run bitumen or cut back bitumen binder, the aggregate shall be dry for the full depth of layer. When emulsion is used, the quantity of emulsion used shall be sufficient to coat the aggregate to the full depth of the layer above the slurried or water bound layer.

(7) Application of Key Aggregate

Immediately after the binder has been applied to the coarse aggregate, key aggregate shall be sprinkled lightly over the surface in sufficient quantity to prevent sticking of the roller wheels. Then this shall be rolled and simultaneously with the rolling additional key aggregate shall be added in small quantities and lightly broomed over the surface while rolling continues until the surface interstices between the coarse aggregate have been filled but without covering the coarse aggregate itself. The surface shall then be rolled until the stone is thoroughly imbedded into the binder and anchored in place. Rolling shall be continued until the surface is hard and smooth and shows no perceptible movement under the roller.

(8) Seal coat

The surface shall be swept clean of all loose material and treated with a second coat a binder and cover aggregate as specified in Clause 1303.

(9) Protection of Pavement

The seal coat shall be applied as soon as practicable after the application of the choke aggregate and the surface course shall be protected from all traffic (other than that essential to the construction) until the completion of the seal coat.

(10) Tolerances

Penetration macadam course shall be set out and constructed to the tolerances given in Section 1100 of this Specification.

The actual rate of application of binder across the lane width shall not vary more than ±% of the rate ordered and for each single run of the spray shall not vary from the specified rate by more than 0.03 litre per square metre.

The actual rate of application of chippings for each single run of the chip-spreader shall not vary by more than ±5% or the rate ordered.

(11) Testing

(a) Process Control

The minimum testing frequency for the purpose of process control shall be given in the Table 13.12.

Table 13.12: Minimum Testing Frequency

Test	Minimum number of tests
MATERIALS:	
AGGREGATE:	
Grading	One test every 100 m^3 or part of it and in every change of source
Los Angeles	One test every 500 m^3 or part of it and in every change of source
Aggregate Impact Value	One test every 500 m^3 or part of it and in every change of source
Sodium Sulphate Soundness	One test every 500 m^3 or part of it and in every change of source
BITUMINOUS BINDERS:	
Quality of Binder	***The Contractor shall produce certificates from all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each 50,000 litres or part of it of supply of binder
Temperature for Application	At close intervals
Rate of Application of Binder and chippings	Two tests per run

CONSTRUCTION TOLERANCES:	
Width	200m or at close intervals
Surface levels	10m or at close intervals
Layer thickness	500m or at close intervals
Smoothness	All apparently rough areas to be checked.

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out to test the materials and workmanship for compliance with the requirements specified in this Section.

Any material or workmanship that does not comply with the requirements specified, shall be replaced with materials and workmanship complying with the Specifications or, be repaired so that after being repaired it shall comply with the requirements specified.

(12) Measurement

Penetration macadam course shall be measured as finished work in square metres.

Seal coat shall be measured as per Sub-clause 1303.

(13) Payment

The penetration macadam shall be paid as per contract unit rate which shall be the full and the final compensation to the Contractor for the cost of preparation of existing surface, providing, hauling and spraying bituminous binder, coarse and choke aggregates and complying with Clauses 1301 and 1304 in addition to those specified in Clause 112.

Seal coat shall be paid as provided in Clause 1303.

(14) Adjustment in Contract Unit Rate.

Should there be any variation between the specified (nominal) rate of application of binder, coarse aggregate and/or chok aggregate and their respective rate of application actually used in the work as per direction of the Engineer, the contract unit rate for penetration macadam shall be adjusted based on contract unit rate of the respective material quoted by the Contractor for the purpose of this adjustment.

The varied penetration macadam shall be paid as per adjusted rate.

1305. SAND SEAL

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of sand seal.

(2) Definition

A sand seal means an application of bituminous binder covered with aggregate as specified hereunder.

(3) Materials

(a) Binder

The binder shall be a medium-curing cut-back MC-800 or MC-3000 or K1-60 cationic emulsion unless otherwise specified.

(b) Fine Aggregate

The aggregate shall consist of sand, or fine screenings free from organic matter, clay and other deleterious materials. The fines (passing a 0.425 mm sieve) shall be non-plastic. The grading shall be as specified in the Table 13.13.

Table 13.13: Grading of Aggregate

Sieve (mm)	Percentage passing by weight
10.00	100
4.75	70-90
2.36	45-70
0.60	15-35
0.15	0-2

The material shall be wet screened to ensure all material greater than 100 mm is eliminated together with dust and foreign matter.

(4) Rate of Application of Binder and Fine Aggregate

The rate of spray of binder and the rate of spread of the fine aggregate shall be as specified in the Special Specification or as provided in the BOQ or as instructed by the Engineer.

During the sand sealing operation tray tests to determine spray rate of binder and spread rate of fine aggregate shall be carried out at least twice per spray run.

(5) Construction

The surface to be covered shall be prepared in accordance with Sub-clause 1303 (7).

The binder shall be uniformly at the specified rate. After this, the fine aggregate shall be uniformly spread and rolled, all in accordance with Sub-clause 1303 (8).

(6) Aftercare and Control of Traffic

The road shall be opened to traffic when instructed by the Engineer.

Traffic speed shall be restricted as per Sub-clause 1303 (9) for as long as the Engineer may require.

Any whipped-off aggregate shall be broomed back onto the road, as many times as are necessary for it to adhere fully to the binder.

(7) Tolerance

Sand seal shall be constructed within the same width tolerance as given in Sub-clause 1303 (11) for surface dressing.

The actual rate of application of binder across the lane width shall not vary be more than ±5% of the rate ordered and for each single run of the spray shall not vary from the specified rate by more than 0.003 litre per square metre.

The actual rate of application of fine aggregate along and across the lane width for each single run of the chip spreader shall not vary by more than ±5% of the rate ordered.

(8) Testing

(a) Process Control

The minimum testing frequency required for the process control shall be as given in the Table 13.14.

Table 13.14: Minimum Testing Frequency

Test	Minimum number of tests
Grading	One test every 50 m^3 or part of it and in every change of source
Plasticity Index	One test every 50 m^3 or part of it and in every change of source
Quality of Binder	***The Contractor shall produce certificates from all suppliers to the effect that all material supplied by them comply with the relevant Specifications.***

	In addition, one set of tests for each 50,000 litres or part of it of supply of binder
Temperature for Application	At close intervals
Rate of Application of Binder	Two tests per run

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out to test the materials and workmanship for compliance with the requirements specified in this Section.

Any materials or workmanship that does not comply with the requirements specified, shall be replaced with materials and workmanship complying with the specifications or , be repaired so that after being repaired it shall comply with the requirements specified.

(9) Measurement

Sand seal shall be measured as finished work in square metre.

(10) Payment

Payment for sand seal shall be as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements specified in Clause 1301 and 1305 in addition to those specified in Clause 112.

(11) Adjustment in Contract Unit Rate

Should there be any variation between the specified rates of binder and/or aggregate and their actual rate of application as per the instruction of the Engineer respectively, the contract unit rate for sand seal shall be adjusted based on contract unit rates of these materials quoted by the Contractor for the purpose of adjustment.

The varied work shall be paid as per adjusted rate.

1306. SLURRY SEAL

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of slurry seal.

(2) Definition

Slurry seal means a mixture of bitumen emulsion, fine aggregate, cement or lime and water prepared in a mixer and then spread on the road surface.

(3) Materials

(a) Emulsion

The emulsion shall be either and anionic emulsion A4 (slow setting) or a slow-acting cationic emulsion K3 unless otherwise instructed by the Engineer.

(b) Aggregate

The aggregate shall be free of organic matter, clay silt or other deleterious matter. It shall have a Sand Equivalent of at least 50.

The grading curve shall be within one of the envelopes provided in the Table 13.15 or as specified in the Special Specification or in the Bill or Quantities.

Table 13.15: Grading Envelopes of Aggregate

Sieve Size (mm)	Percentage passing by weight		
	Type I (Fine)	Type II (General)	Type III (Coarse)
10.00	-	-	100
4.750	100	90-100	70-90
2.360	90-100	65-90	45-70
1.180	65-90	45-70	28-50
0.600	40-60	30-50	19-34
0.300	25-42	18-30	12-25
0.150	15-30	10-21	7-18
0.075	10-20	5-15	5-15

(c) Cement/Lime

Cement and lime shall comply with the requirements of Section 600.

(4) Preparation of the Slurry Mix

The proportion by weight of dry aggregate, bitumen emulsion and cement or lime shall be specified in the Special Specification or in the Bill of Quantities. This shall be termed the nominal proportions of bitumen emulsion and cement or lime.

Water shall be added in sufficient quantity to obtain the correct slurry consistency as directed by the Engineer.

The slurry mixture shall be prepared in the presence of the Engineer in a slurry mixer acceptable to him. The mixer shall be charged with materials in the proportions specified.

The mixing cycle shall be sufficient to produce a uniform coating of the aggregate and a uniform consistency of the slurry. It shall continue until the slurry mixture is discharged into the spreader box or onto the road surface. The entire batch shall be discarded, if there is evidence that the emulsion has broken. The slurry, ready for application, shall be a smooth, free flowing mixture throughout.

(5) Rate of Application of Slurry Mixture

The rate of application of the slurry mixture shall be as specified in the Special Specifications or as instructed by the Engineer.

Tray tests shall be carried out at least two tests for every 1000 square metre of spray during slurry seal operations.

(6) Construction

Where a slurry seal is to be applied to a surface dressing, the surface dressing shall be trafficked for a period of at least two prior to the application of the slurry seal.

The surface to be covered shall be prepared in accordance with Sub-clause 1303 (7).

Unless otherwise agreed by the Engineer, the slurry mixture shall be evenly spread by a slurry machine at the specified rate.

The surface immediately ahead of the spreader shall be slightly dampened, unless otherwise instructed by the Engineer. Slurry seal shall receive at least 6 passes of the pneumatic tyred roller unless otherwise directed by Engineer. The rolling shall commence as soon as the slurry has set sufficiently to ensure that no rutting or pick up will occur.

The finished slurry seal shall be of uniform surface texture and colour throughout the work. The finished surface shall be free from blow-holes and irregularities.

(7) Curing and Control of Traffic

All traffic shall be kept off the slurry seal until it has cured to a firm condition to prevent pick-up of the mixture. Where two application of

slurry are required, the initial treatment shall be cured thoroughly prior to placing the succeeding application.

(8) Tolerance

Slurry seal shall be constructed within the same width tolerance given in Sub-Clause 1303 (11).

The rate of application of slurry seal across the width of a lane sealed in a single pass shall not vary be more than ±5% of the rate ordered, and the average rate of application along the length of a single pass shall be not less than the rate ordered.

(9) Testing

(a) Process Control

The minimum testing frequency required for the process control shall be as given in the Table 13.16.

Table 13.16: Minimum Testing Frequency

Test	Minimum number of tests
Grading	One test every 50 m^3 or part of it and in every change of source
Plasticity Index	One test every 200 m^3 or part of it and in every change of source
Quality of Binder	***The Contractor shall produce certificates from all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each2,000 litres or part of it of supply of binder
Temperature for Application	At regular close intervals
Rate of Application of Binder	Two tests per 1000 sq.m or part of it

(b) Routine Inspection and Testing

Routine inspection and testing shall be carried out to test the materials and workmanship for compliance with the requirements specified in this Section.

Any materials or workmanship that does not comply with the requirements specified, shall be replaced with materials and workmanship complying with the specifications or , be repaired so that after being repaired it shall comply with the requirements specified.

(10) Measurement

Slurry seal shall be measured as finished work in square metre.

(11) Payment

Slurry seal shall be as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements specified in Clause 1301 and 1306 in addition to those specified in Clause 112.

(12) Adjustment in Contract Unit Rate

Should there be any variation between the specified rates of binder and/or aggregate and their actual rate of application as per the instruction of the Engineer respectively, the contract unit rate for sand seal shall be adjusted based on contract unit rates of these materials quoted by the Contractor for the purpose of adjustment.

The varied work shall be paid as per adjusted rate.

1307. GENERAL REQUIREMENTS FOR ASPHALT CONCRETE, SAND ASPHALT, EMULSION AGGREGATE MIX AND COLD ASPHALT.

(1) Scope

This Clause comprise all the general requirements for bituminous mixes which shall apply to Clause 1308 to Clause 1311.

(2) Construction Plant

(a) General

The Contractor shall submit to the Engineer full details of the construction plant he proposes to use and the procedures he proposes to adopt for carrying out the permanent works.

The Engineer shall have access at all times to construction plant for the purpose of inspection. The Contractor shall carry out regular calibration checks in the presence of the Engineer and shall correct forthwith any faults found.

All construction plant used in the mixing, laying an compacting of bituminous mixes shall be of adequate capacity, in good working condition and shall be acceptable to the Engineer.

(b) Mixing Plant

Bituminous materials shall be mixed in a plant complying with ASTM Designation D995 and shall be located on the Site unless otherwise agreed by the Engineer. It shall be equipped with at least three bins

for the storage of heated aggregates and a separate bin for filler. All bins shall be covered to prevent the ingress of moisture.

The plant may be either batch-mix type or the continuous-mix type and shall be capable or regulating the composition of the mixture to within the tolerances specified in Sub-clause 1307 (13).

The bitumen tank shall be capable of maintaining its contents at the specified temperature within a tolerance of plus or minus 5^{o} C and shall be equipped with a thermostat to prevent the temperature rising above 180^{o} C and a fixed thermometer easily read from outside the tank. Any bitumen which has been heated above 180^{o} C or has suffered carbonization from prolonged heating shall be removed from the plant and disposed off.

(c) Laying Plant

Bituminous materials shall be laid by a self propelled spreader finisher equipped with a hopper, delivery augers and a heated adjustable vibrating screed. It shall be capable of laying bituminous materials with no segregation, dragging, burning or other defects and within the specified level and surface regularity tolerances. Delivery augers shall terminate not more than 200 mm from the edge plates.

(d) Compaction Plant

The Contractor shall provide sufficient rollers of adequate size and weight to achieve the specified compaction. Prior to commencing the laying of bituminous mixes in the permanent works the Contractor shall carry out site trials in accordance with Section 500 to demonstrate the adequacy of his plant and to determine the optimum method of use and sequence of operation of the rollers.

(3) Preparation of Surface

Immediately before placing the bituminous mix in the pavement, the existing surface shall be cleaned of all loose materials and foreign matter with mechanical brooms or by other approved methods. The debris shall be deposited well clear of the surface to be covered.

Any defect of the surface shall be made good and no bituminous mix shall be laid until the surface has been approved by the Engineer.

If instructed by the Engineer a tack coat shall be applied in accordance with Clauses 1301 and 1302. If the Engineer considers a tack coat is required prior to laying the bituminous mix or between layers of the bituminous mix, due solely to the Contractor's methods of working, then such tack coat shall be at the Contractor's expense.

(4) Design and Working Mixes

The Contractor shall demonstrate that he can produce aggregate meeting the grading requirements of the Specification.

At least two months prior to commencing work using a bituminous mix, the Contractor shall having demonstrated that he can produce aggregates meeting the grading requirements of the Specification, submit samples of each constituent of the mix to the Engineer.

The maximum size of the aggregate for wearing course shall equal to or less than the thickness of wearing course divided by 2.5 and that for binder course shall equal to or less than thickness or binder course divided by 2.

The Contractor shall then carry out laboratory tests in order to propose the proportions of each consistent of the initial mix or mixes to be used for site trials to be carried out in accordance with Sub-clause 1307 (5).

Shall the Engineer conclude form the site trials that the mix proportions or aggregate gradings are to be changed, the Contractor shall submit further samples of the constituents, carry out further laboratory and site trials as directed by the Engineer.

The Engineer may instruct the alteration of the composition of the aggregate passing through 0.075 mm by the addition or substitution of mineral filler.

Following laboratory and site trials the determined proportions of the mix agreed by the Engineer shall become the basis of the working mix and the Contractor shall maintain this composition within the tolerances given in Sub-clause 1307 (13).

Any changes in the nature or source of the materials, the Contractor shall inform the Engineer accordingly. The procedure set out above shall be followed in establishing the new mix design also.

(5) Site Trials

Full scale laying and compacting site trials shall be carried out by the Contractor on all asphalt pavement materials proposed for the works using the construction plant and methods proposed by the Contractor for construction the works. The trials shall be carried out at a location approved by the Engineer in his presence.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of his mixing and compaction equipment to provide and compact the materials to the specified voids content and confirm that the other specified requirements of he completed asphalt pavement layer can be achieved.

Each trials area shall be at least 100 metres long to the full construction width and depth for the material. It may form part of the Works provided it complies with this Specification. Any areas which do not comply with this Specification shall be removed.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests on them. The trial on any pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence the full scale work on that layer.

The Contractor shall compact each section of trial over therange of compactive effort the Contractor is proposing. The following data shall be recorded for each level of compactive effort at each site trial.

(i) The composition and grading of the material including the bitumen content and type and grade of bitumen used.

(ii) The moisture content of aggregate in the asphalt plant hot bins.

(iii) The temperature of bitumen and aggregate immediately prior to entering the mixer, the temperatures of the mix on discharge from the mixer and the temperature of the mix on commencement of laying, on commencement of compaction and on completion of compaction. The temperatures of the mixture is to measured in accordance with BS 598, Part 109.

(iv) The type, size, mass, width of roll, number of wheels, wheel load, tyre pressures, frequency of vibration and the number of passes of the compaction equipment, as appropriate for the type of roller.

(v) The target voids and other target properties of the mix together with the results of the laboratory tests on the mix.

(vi) The density and voids achieved.

(vii) The compacted thickness of the layer.

(viii) Any other relevant information as directed by the Engineer.

At least eight sets of tests shall be made by the Contractor on each 100 metres of trial for each level of compactive effort and provided all eight sets of results over the range of compactive effort proposed by the Contractor meet the specified requirements for the material then the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements.

During the execution of the works, if the Construction control/process control tests indicate that the requirements for a material are not consistently

achieved then work on that layer shall be stopped until the cause is investigated by the Contractor. Such investigation may include further laboratory and/or site trials on the material to determine a revised set of data as described above which when agreed, shall be the basis on which all subsequent material shall be provided and processed to achieve the specified requirements.

Agreement of the Engineer to a set of data recorded in a site trial shall not relieve the Contractor of any responsibility to comply with the requirements of this Specification.

(6) Mixing of Aggregate and Bitumen

The bitumen shall be heated so that it can be distributed uniformly. Care shall be taken not to overheat it. The temperature shall never exceed 170^{o} C for 80/100 or 60/70 bitumen.

The aggregate shall be dried and heated so that they are mixed at the following temperatures unless otherwise specified in Clause 1308 to 1311.

125^{o} - 165^{o} C when 80/100 bitumen is used,
130^{o} - 170^{o} C when 60/70 bitumen is used.

The dried aggregates shall be combined in the mixer in the amount of each fraction of the agreed mix and the bitumen shall then be introduced into the mixer in the amount specified. The materials shall then be mixed until a complete and uniform coating of the aggregate is obtained.

The mixing time shall be the shortest required to obtain a uniform mix and thorough coating. The wet mixing time shall be determined by the Contractor and agreed by the Engineer for each plant and for each type of aggregate used. It shall normally not exceed 60 seconds.

(7) Transportation of the Mixture

The bituminous mix shall be kept free of contamination and segregation during transportation. Each load shall be covered with canvas or similar covering to protect it from dust and adverse effect of the weather.

(8) Laying of the Mixture

Immediately after the surface has been prepared and approved, the mixture shall be spread to line and level by the laying plant without segregation and dragging.

The mixture shall be place in widths of one traffic lane at a time, unless otherwise agreed by the Engineer. The compacted thickness of nay layer shall be at least 2.5 times the maximum size of the aggregate for wearing

course and at least 2 times the maximum size of the aggregate for binder course.

Only on area where irregularities or unavoidable obstacles make the use of mechanical laying impracticable, the mixture may be spread and compacted by hand.

(9) Compaction

Immediately after the bituminous mixture has been spread, it shall be thoroughly and uniformly compacted by rolling.

The layer shall be rolled when the mixture is in such a condition that rolling does not cause undue displacement or shoving.

The number, weight and type of rollers furnished shall be sufficient to obtain required compaction while the mixture is in a workable condition. The sequence of rolling operations shall be as agreed with the Engineer.

Initial rolling with a steel tandem of three-wheeled roller shall follow the laying plant as closely as possible. The rollers shall be operated with the drive roll nearest the laying plant, at a slow and uniform speed (not exceeding 5 km/h).

Rolling shall normally commence from the outer edge and proceed longitudinally parallel to the centerline, each trip overlapping one half of the roller width. On superelevated curves, rolling shall begin at the low side and progress to the high side. Where laying is carried out in lanes care must be taken to prevent water entrapment.

Intermediate rolling with a pneumatic tyred or vibratory roller shall follow immediately. Final rolling with a steel wheeled roller shall be used to eliminate marks from previous rolling.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept lightly moistened with water.

In areas too small for the roller, a vibrating rate plate compactor or a hand tamper shall be used to achieve the specified compaction.

(10) Finishing, Joint and Edges

Any mixture that becomes loose and broken, mixed with dirt or foreign matter or is in any way defective, shall be replaced with fresh hot mixture, which shall be compacted to conform with the surrounding area.

Spreading of the mixture shall be as continuous as possible. Transverse joints shall be formed by cutting neatly in a straight line across the previous run to expose the full depth of the course. The vertical face so formed shall

be painted lightly with hot 80/100 penetration grade bitumen just before the additional mixture is placed against it.

Longitudinal joints shall be rolled directly behind the paving operation. The first lane shall be placed true to line and level an approximately vertical face. The mixture placed in the abutting lane shall than be tightly crowded against the face of the previously placed lane. The paver shall be positioned to spread material overlapping the joint face by 20 – 30 mm. Before rolling, the excess mixture shall be raked off and discarded.

When the abutting lane is not placed in the same day, or the joint is destroyed by traffic, the edge of the lane shall be cut back as necessary, trimmed to line and painted lightly with hot 80/100 penetration grade bitumen just before the abutting lane is placed.

Any fresh mixture spread accidentally on the existing work at a joint shall be carefully removed by brooming it back on to uncompacted work, so as to avoid formation of irregularities at the joint. The finish at joints shall comply with the surface requirements and shall present the same uniformity of finish, texture and density as other sections of the work.

The edges of the course shall be rolled concurrently with or immediately after the longitudinal joint. In rolling the edges, roller wheels shall extend 50 to 100 mm beyond the edge.

(11) Sampling of Bituminous Mixtures

The sampling of bituminous mixture shall be carried out in accordance with ASTM Designation D979.

(12) Quality of Testing

During mixing and laying of bituminous mixtures, control tests on the constituents and on the mixed material shall be carried out in accordance with Section 600 and relevant Clauses of Section 1300.

If the results of any tests show that any of the constituent materials fail to comply with this Specification, the Contractor shall carry out whatever changes may be necessary to the materials and/or to the source of supply to ensure compliance.

If the results of more than one test in ten on the mixed material show that the material fails to comply with this Specification, laying shall forthwith cease until the reason for the failure has been found and corrected. The Contractor shall replace any faulty material laid with material complying with this Specification all at his expense.

(13) Tolerance

Surfacing and base shall be constructed within the geometric tolerance specified in Section 1100.

The Contractor shall maintain the composition of the mixture as determined from the laboratory and site trials with the following tolerances, per single test:-

(a) Bitumen :_ 0.3% of (total weight of bitumen in total mix)

(b) Aggregates

(i)	Passing through 10 mm sieve and larger sieves	:- 6% of	(Total weight of dry aggregate including mineral filler)
(ii)	Passing through 10 mm sieve and retained on 1mm sieve	:- 4% of	
(iii)	Passing through 1 mm sieve and retained on0.075 mm sieve	:- 3% of	
(iv)	Passing through 0.075 mm sieve	:- 2% of	

The average amount of bitumen in any length of any layer, calculated as the product of the bitumen contents obtained from single tests and the weight of the mixture represented by each tests, shall not vary beyond the limit of tolerance of the amount specified.

The average amount of bitumen for each day's production calculated form the check weights of mix shall not vary beyond the limits of tolerance of the amount specified.

The final average overall width of the upper surface of a bituminous mix layer measured at six equidistant points over a length of 100 m shall be at least equal to the width specified. At no point shall the distance between the centerline of the road and the edge of the upper surface of a bituminous mix layer be narrower than that specified by more than 13 mm.

(14) Measurement and Payment

No separate measurement and payment shall be made for complying with the requirements of the Clause 1307. The Contractor shall allow compensation for compliance of the Clause 1307 in the rates of items covered by Clauses form 1308 to 1311.

1308. ASPHALT CONCRETE

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of Asphalt Concrete.

(2) Definition

Asphalt Concrete means a thoroughly controlled, hot-mixed, hot-laid, plant mixture of well graded dried aggregate and penetration grade bitumen, which compacted, forms a dense material.

(3) Materials

(a) Penetration Grade Bitumen

Bitumen shall be 80/100 or 60/70 penetration grade as specified in Section 600.

(b) Aggregate

Coarse aggregate (retained on a 4.75 mm sieve) shall consist of crushed stone free form clay, silt, organic matter and other deleterious substances. The coarse aggregate shall comply with the requirements given in the Table 13.17

Table 13.17: Requirement of Coarse Aggregate

Coarse Aggregate (retained on 4.75 mm Sieve)		
Aggregate Class	**A**	**B**
LAA Max.	25	30
ACV Max.	20	20
SSS Max.	12	12
FI Max.	20	25

The coarse aggregate shall be entirely crushed. The aggregates shall be clean, free from weathered or decomposed stone, organic matter, shale, clay and other substances which, in the opinion of the Engineer may be deleterious to the mixture.

Fine aggregate (passing a 4.75 mm sieve) shall be free from clay, silt organic and other deleterious matter and shall be non-plastic. It shall consist of entirely crushed rock produced from stone having a Los Angeles Abrasion of not more than 30. The Sand Equivalent of the fine aggregate shall be not less than 60, and the SSS not more than 12.

(c) Mineral Filler

Mineral filler shall consist of finely ground particles of limestone, hydrated lime, ordinary Portland cement or other non-plastic mineral mater. It shall be thoroughly dry and free from lumps. At least 75% (by weight) shall pass a 0.075 mm sieve and 100% shall pass a 0.425 mm sieve. It shall have a bulk density between 0.5 and 0.9 g/ml measured in accordance with BS 812-2.

(4) Grading Requirements

The grading of the mixture of coarse and fine aggregate shall be within and approximately parallel to one of the grading envelopes given in Table 13.18 or as specified in the Special Specification or in the Bill of Quantities.

Table 13.18: Grading Requirements of the Mixture of Coarse and Fine Aggregate

Sieve Size (mm)	Percentage passing by weight		
	Wearing course		Binder course
	Type I ((0/16)	Type II (0/10)	0/20
20.000	-	-	100
16.000	100	-	96-100
10.000	76-82	100	75-100
4.750	54-59	64-70	48-90
2.360	33-37	39-47	24-62
0.600	16-21	21-28	12-24
0.075	6-9	6-9	3-8

(5) Requirement for Asphalt Concrete

Asphalt concrete i.e. the mixture of binder, coarse and fine aggregate and mineral filler, if any, shall comply with the requirements given in the Table 13.19

Table 13.19: Requirements of Asphalt Concrete

Asphalt Concrete	Wearing course	Binder course
Marshall Stability 50 blows (N)	Min 8 000	Min 6 000
Flow Value (mm)	2-3	2-3
Voids in Total Mix (%)	2-4	3-7
Compression/Immersion Ratio	>0.75	>0.75

The proportion, by weight of total mixture, of bitumen shall be stated in the Special Specification or in the Bill of Quantities. This shall be termed the nominal binder content. The binder content of the working mix shall be instructed by the Engineer following laboratory and site trials.

(6) Mixing and Laying of Asphalt Concrete

The Temperature of the bitumen when mixed with the aggregate shall be between 120^{o} C and 140^{o} C.

The minimum temperature of the mixture at the commencement of compaction shall be 125^{o} C. The minimum temperature at completion of compaction shall be 80^{o} C.

The minimum thickness of the compacted layer in wearing course shall be 25 mm or 40 mm when 0/10 or 0/16 aggregate is used respectively and that binder course shall be 40 mm when 0/20 aggregate is used.

(7) Compaction

Rolling shall be continued until the voids measured in the completed layer are within the appropriate ranges tabulated in the Table 13.19. Rolling shall be carried out by a sequence of roller in such a manner that it shall ensure the full specified compaction and at the same time it will provide a finished surface within the tolerance laid down in this Specification.

The average density after compaction shall not be less than 98% of the average density obtained from Marshall specimens (50 blows) made during laboratory trials on the mixture used for site trials. No individual density shall be below 95% of the average of the laboratory specimens.

(8) Testing

(a) Sampling

Prior to use the Contractor shall supply the Engineer with samples of all materials proposed to be used. The Contractor shall carry out all the specified tests as the Engineer may require to satisfy himself that the material and proportions satisfy this Specification. No material shall be used, nor job mix adopted until they are approved in writing by the Engineer.

Sampling of mixes shall normally be carried out at the mixing plant or from lorries conveying the material from the mixing plant to the paver, but the Engineer may direct for sampling to be carried out form the paver, if there is any danger of segregation of the mix during transporting and spreading process.

(b) Process Control

The minimum testing frequency required for the process control shall be as provided in the Table 13.20.

Table 13.20: Minimum Testing Frequency

Test	Minimum number of tests
AGGREGATE:	
Grading	One test every 100 m^3 or part of it and in every change of source
Los Angeles	One test every 500 m^3 or part of it and in every change of source
Aggregate Impact Value	One test every 500 m^3 or part of it and in every change of source
Flakiness Index	One test every 100 m^3 or part of it and in every change of source
SSS	One test every 500 m^3 or part of it and in every change of source
Sand Equivalent	One test every 500 m^3 or part of it and in every change of source
Quality of Filler	" " 50 tonnes " " "
BITUMEN:	
Quality of Binder	***The Contractor shall produce certificates from the concemed all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each 50,000 litres or part of it of supply of binder
Penetration Test	Daily
MIXTURE:	
Grading and bitumen content	One test for each 100 toones of mix or part of it.
Marshall stability, flow and voids	One test for each 100 toones of mix or part of it.
Control of Temperature	As required
CONSTRUCTION TOLERANCES:	
Compaction	One test per 500 m^2 or part of it
Surface levels	Every 10 m or at close intervals
Smoothness	Every 50 m^2 or at close intervals.

(9) Measurement

Asphalt concrete shall be measured cubic metre calculated as the product of the length and the compacted cross-sectional area of the asphalt concrete laid as per Drawing or as instructed by the Engineer.

(10) Payment

The asphalt concrete shall be paid as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements specified in Clause 1307 and 1308 in addition to those specified in Clause 112.

(11) Adjustment in Contract Unit Rate

Should there be any variation between the specified (nominal) rates of application of binder, coarse aggregate fine aggregate and/or mineral filler and their respective rate of application actually used in the work as per the direction of the Engineer, the contract unit rate for asphalt concrete shall be adjusted as per contract unit rate of the respective material quoted by the Contractor for the purpose of this variation.

The varied asphalt concrete shall be paid as per adjusted rate.

1309. SAND ASPHALT

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of Sand Asphalt.

(2) Definition

Sand Asphalt means a controlled, hot-mixed, hot-laid, plant mixture of sand and penetration grade bitumen.

(3) Materials

(a) Sand

Sand shall consist of clean, tough, screened or crushed rough surfaced grains. As delivered to the mixer it shall be free from lumps or loosely bonded aggregations and the individual particles shall be free form adhering dust. It shall be non-plastic and Sand Equivalent shall be not less than 40. The grading shall be within the limits set out in the Table 13.21.

Table 13.21: Grading Requirement of Sand

Sieve Size (mm)	Percentage passing by weight
4.750	100
2.360	76-100
0.600	27-90
0.075	6-14

Sand which fails to meet this requirement may be used provided it is first mixed with other mineral products to produce a mixture which falls within the grading limits of Table 13.21 and has the specified Marshall test stability.

(b) Mineral Filler

The mineral filler shall comply with Sub-Clause 1308 (3) (c).

(c) Binder

The binder shall be straight-run bitumen of 80/100 penetration complying with the requirements specified in Section 600.

(4) Requirements for Sand Asphalt

The mixture shall comply with the following requirement:

- Marshall Stability 50 blows (N): Min. 3,500

The proportion, by weight of total mixture, of bitumen shall be stated in the Special Specification or in the Bill of Quantities. This shall be termed the nominal binder content. The binder content of the working/job mix shall be instructed by the Engineer following laboratory and site trials. The Contractor shall carry out such tests as the Engineer may require to determine the optimum mix composition of the job mix.

(5) Mixing and Laying Sand Asphalt

The mixture shall be transported, laid and compacted in accordance with Clause 1307. The minimum temperature of the mixture at the time of completion of rolling shall be not less than 80^{o} C.

(6) Compaction

Rolling shall be sequence of roller in such a manner that it will ensure the full specified compaction and at the same time will provide a finished surface within the tolerance laid down in this Specification.

The minimum in-situ density shall be 87% of the density of the Marshall specimens compacted form the Approved Job Mix.

(7) Testing

(a) Sampling

Prior to use the Contractor shall supply the Engineer with samples of all materials proposed to be used. He shall carry out all the specified tests as the Engineer may require to satisfy himself that the material and proportions satisfy this Specification. No material shall be used, nor job mix adopted until they are approved in writing by the Engineer.

Sampling of mixes shall normally be carried out at the mixing plant or from lorries conveying the material from the mixing plant to the paver,

but the Engineer may direct for sampling to be carried out form the paver, if there is any danger of segregation of the mix during transporting and spreading process.

(b) Process Control

The minimum frequency of testing for process control shall be as given in the Table 13.22
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Table 13.22: Minimum Testing Frequency

Test	Minimum number of tests
AGGREGATE:	
Grading	One test every 100 m^3 or part of it and in every change of source
Sand Equivalent	One test every 500 m^3 or part of it and in every change of source
Quality of Filler	" " 50 tonnes " " "
BITUMEN:	
Quality of Binder	***The Contractor shall produce certificates from the concemed all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each 50,000 litres or part of it of supply of binder
Penetration Test	At close intervals as directed by the Engineer.
MIXTURE:	
Grading and bitumen content	One test for each 100 toones of mix or part of it.
Marshall stability, flow and voids	One test for each 100 toones of mix or part of it.
Control of Temperature	As required
CONSTRUCTION TOLERANCES:	
Compaction	One test per 500 m^2 or part of it
Surface levels	Every 10 m or at close intervals
Smoothness	Every 50 m^2 or at close intervals.

(c) Process Control

Routine inspection and testing shall be carried out by the Engineer to test the completed work for compliance with the dimensional tolerances, quality of material, density of compaction and any other requirements stated in this Specification.

Any material and workmanship that do not comply with the requirements specified, shall be replaced by material and workmanship complying with their respective Specification.

(8) Measurement

Sand Asphalt concrete shall be measured cubic metre as the product of the length and the compacted cross-sectional area of the sand asphalt laid as per drawing or as instructed by the Engineer.

(9) Payment

The sand asphalt shall be paid as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements specified in Clause 1307 and 1309 in addition to those specified in Clause 112.

(10) Adjustment in Contract Unit Rate

Should there be any variation between the specified (nominal) rates of application of binder, sand and/or mineral filler and their respective rate of application actually used in the work as per the direction of the Engineer, the contract unit rate for asphalt concrete shall be adjusted as per contract unit rate of the respective material quoted by the Contractor for the purpose of this variation.

The varied sand asphalt shall be paid as per adjusted rate.

1310. EMULSION AGGREGATE MIX

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of Emulsion Aggregate Mix.

(2) Definition

Emulsion aggregate mix means a clod-mixed, cold-laid, plant mixture of graded aggregate and emulsion. This material shall be designed, produced, laid and tested generally in accordance with the documents listed below, except where otherwise added to or amended in this Specification:

(a) A Basic Asphalt Emulsion Manual, Asphalt Institute, Manual Series 19, Second Edition.

(b) Bitumen Emulsion, general information applications, Syndicate Des Fabricants d' Emulsion Routieres, March 1991.

(3) Materials

(a) Emulsion

Emulsion for the work shall be slow-setting K3-60 or A3-60 and produced from penetration grade 80/100 or 180/200 bitumen. It shall comply with the requirements specified in Section 600.

If emulsion is ordered ready-made, the manufacturer must provide a certificate with each batch confirming compliance with these tests. For site production all tests shall be carried out at least before mix trials to confirm compliance.

It shall be preferable that the emulsion is used as soon as possible after its production. If it is to be delivered to site and/or stored after delivery or after production on site, this storage time shall not exceed the maximum indicated by the storage ability results above, and appropriate facilities shall be provided to re-homogenise the emulsion before use if it is found to have settled out during storage.

(b) Water for Manufacture of Emulsion and Mix Production

This shall comply with all requirements for water of potable quality and be free of all substances likely to adversely affect either process.

(c) Mineral Aggregate

Before approval is granted for the use of aggregate and fillers in laboratory mix design of emulsion, aggregate mix samples shall be taken and submitted for the tests prescribed in this clause to ensure that the aggregates and filler comply with the specified requirements. Mineral aggregate for emulsion aggregate mix shall consist of (i) coarse aggregate (ii) fine aggregate and (iii) added filler as required.

(i) Coarse Aggregate

Coarse aggregate shall be the material passing 20 mm and retained on 4.75 mm sieves and shall consist of clean, mechanically crushed rock or gravel with a Crushing Index of 100% (i.e. the raw feed to the crusher must be material retained on a 20 mm sieve).

The coarse aggregate shall have the following properties:

- Los Angeles Abrasion Value: maximum 35%
- Sodium Sulphate Soundness: <12%
- Particles with 2 or more fractured faces: at least 75% by Weight

(ii) Fine Aggregate

This shall be the material passing a 4.75 mm sieve and shall consist of crushed sand, or a combination of cursched and natural sand. It shall comply with the following requirement:

- Sodium Sulphate Soundness: <12%
- Sand Equivalent: >40

(iii) Filler

Filler, if required, shall comply with Sub-clause 1308 (3) (c).

(iv) Combined Aggregate

Where coarse and fine aggregates are produced from the same screening or crushing operation and laboratory test indicate that their combined grading is inconsistent or unlikely to meet specified mix requirements, they shall be stockpiled separately and re-blended later as appropriate. The combined aggregate of the proposed mix, including added natural sand or filler shall be clean, free from weathered or decomposed stone, organic matter shale, clay and other substances which in the opinion of the Engineer may be deleterious to the mixture. The fraction passing the 0.425 mm sieve shall be non-plastic.

The combined aggregate grading shall fall within the limits given in the Table 13.23.

Table 13.23: Grading Requirement of Combined Aggregate

Sieve Size (mm)	Percentage passing by weight
20	100
10	76-92
2.36	42-50
0.6	26-35
0.075	5-10

(4) Requirements for Sand Asphalt

The proportion, by weight of total mixture, of bitumen shall be stated in the Special Specification or in the Bill of Quantities. This shall be termed the nominal binder content. The binder content of the working/job mix shall be instructed by the Engineer following laboratory and site trials. The Contractor shall carry out such tests as the Engineer may require to determine the optimum mix composition of the job mix.

Mix design shall be carried out at least 30 days before production is intended to begin, and shall be generally in accordance with the Duriez test procedure, with the exception that optimum added water content is to be first determined in accordance with Chapter XIV of Asphalt Institute Manual Series No. 19. Sufficient sets of Duriez samples shall be prepared at each emulsion content (by weight of dry aggregates) to investigate effect on mix properties of anticipated variation in the proportion passing through 0.075 mm sieve with a minimum of one set at each extreme of the range (e.g. 5% and 10% fines). The required mix properties at 18^{o} C are:

- Duriz Compactness : 88-95%
- Compression : >3Mpa
- Immersed/dry strength ratio : >0.55

As an alternative, the Contractor may follow Marshall Mix Design Procedure. The required Properties are:

- Stability 50 blows (N) : Min. 5,000
- Flow (mm) : <4

These properties must be maintained within the anticipated range of fines content that shall occur during production.

(5) Production and Laying Trials

When a satisfactory laboratory trial mix has been obtained, trials of this mix and the production and laying processes shall be carried out.

Production plant shall be capable of:

- blending separate classes of aggregates, where necessary, accurately to the required grading and providing a consistent flow of combined aggregate to the mixing chamber.

- providing an accurately-controlled (+/-10% of optimum water content) and metered supply of extra free water as required, and allowing sufficient time for thorough mixing to occur before the addition of emulsion.

- providing an accurately-controlled (+/-10% of optimum water content) and metered supply of emulsion to the mixing chamber and sufficient time for thorough mixing and aggregate coating to occur before discharge. The emulsion pump must be of centrifugal or other type not prone to jamming and/or clogging.

All pipework must be regularly cleaned and maintained to ensure that fencing and/or clogging do not occur.

The mix shall not be prone to segregation. Handling and placement methods shall be such as to avoid segegration.

When the Contractor is satisfied that the plant is producing a consistent mix, he shall propose the laying of a trial area for the Engineer's approval to demonstrate that the properties of the mix produced in the plant are within the specified limits, that the handling and laying processes are capable of laying the mix without segregation or other imperfections to the required thickness, levels and tolerances and that the compaction plant is capable of compacting the mix uniformly to the required density.

The required compaction is 88-95% of the Duriez density of 90-95% of Marshall specimens compacted from Approved Job Mix.

If the optimum moisture content for field compaction is found to be different from that required for coating, the Contractor shall make adequate arrangements to achieve this e.g. by aeration drying or addition of extra water as required.

If the Engineer is satisfied that the mixture meets the Specified requirements and that the Contractor's mixing laying and compaction plant is suitable for and can produce emulsion aggregate mix to the required standard as specified, he shall approve the mix.

(6) Laying and Compaction

Emulsion aggregate mix shall be protected form the weather and contamination by dust etc. during transport, and shall not be laid on surfaces covered by standing water or during rain. The moisture content of the mix shall be adjusted as necessary to ensure that the moisture content at time to compaction is close to the optimum value (90 to 105% of optimum moisture content).

Emulsion aggregate mix may be laid by grader, provided the Contractor can demonstrate in the site trials that he can achieve the geometric tolerances for the base with this method. The minimum thickness of a single layer shall not be less than 80 mm nor more than 120 mm.

Rolling shall be carried out by a sequence in such a manner of roller that it shall be ensure the full specified compaction. Rolling shall be carried out by vibratory or pneumatic rollers in a sequence predetermined and approved during laying of trial Sections and such rolling shall be continued only for so long as it is effective and does not have detrimental effect.

If result form any part of the production, laying and compaction operation fail to meet the specified requirements, an immediate re-test shall be carried out. If the variations continue for more than one day, all mixing shall cease and all plant, materials and processes shall be checked. The Contractor shall make such adjustments or modifications as are necessary to ensure that when mixing restarts the material produced shall comply with these requirements. The cost re-testing and any necessary stoppages, adjustments and replacement of defective material shall be borne by the Contractor.

Any segregated material formed on the edges and interior of the laid area during grading of loose mix to level shall be dug out by hand and either scattered evenly back into the mix or discarded before compaction begings.

(7) Testing

(a) Sampling

Prior to use the Contractor shall supply the Engineer with samples of all materials proposed to be used. The Contractor shall carry out all the specified tests as the Engineer may require to satisfy himself that the material and proportions satisfy this Specification. No material shall be used, nor job mix adopted until they are approved in writing by the Engineer.

(b) Process Control

The minimum frequency of testing for process control shall be as given in the Table 13.24

Table 13.24: Minimum Testing Frequency

Test	Minimum number of tests
AGGREGATE:	
Grading	One test for every 100 m^3 or part of it and in every change of source
Los Angeles Abrasion	One test for every 500 m^3 or part of it and in every change of source
SSS	One test for every 500 m^3 or part of it and in every change of source
Sand Equivalent	One test for every 500 m^3 or part of it and in every change of source
Quality of Filler	" " 50 tonnes " " "
BITUMEN:	
Quality of Binder	***The Contractor shall produce certificates from the concemed all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each 20,000 litres or part of it of supply required.
Water Content	One test for each 100 toones of mix or part of it.
Sieve Test	One test for each 100 toones of mix or part of it.
MIXTURE:	
Grading and bitumen content	One test for each 100 toones of mix or part of it.
Marshall stability, flow or Duriez Test	One test for each 100 toones of mix or part of it.
CONSTRUCTION TOLERANCES:	
Compaction	One test per 500 m^2 or part of it
Surface levels	Every 10 m or at close intervals
Smoothness	Every 50 m^2 or at close intervals.

(c) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Engineer to test the completed work for compliance with the dimensional tolerances, quality of material, density of compaction and any other requirements stated in this Specification.

Any material and workmanship that do not comply with the requirements specified, shall be replaced by material and workmanship complying with their respective Specification.

(8) Measurement

Emulsion aggregate mix shall be measured in cubic metre calculated as the product of the length and the compacted cross-sectional area of the sand asphalt laid as per Drawing or as instructed by the Engineer.

(9) Payment

The emulsion shall be paid as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements specified in Clause 1307 and 1310 in addition to those specified in Clause 112.

(10) Adjustment in Contract Unit Rate

Should there be any variation between the specified (nominal) rates of application of binder, sand and/or mineral filler and their respective rate of application actually used in the work as per the direction of the Engineer, the contract unit rate for asphalt concrete shall be adjusted as per contract unit rate of the respective material quoted by the Contractor for the purpose of this adjustment.

The varied emulsion aggregate mix shall be paid as per adjusted rate.

1311. COLD ASPHALT

(1) Scope

This Clause covers the materials, method of construction and requirements for construction of Cold Asphalt for Surfacing Base, Leveling and Patching.

(2) Definition

Cold Asphalt means a cold-mixed, cold-laid, plant mixture of graded aggregate and bituminous binder

(3) Materials

(a) Bituminous Binder

For cold-asphalt to be used immediately, the bituminous binder shall be an anionic emulsion A2 or A3 or a Cationic emulsion K2 or K3, as specified in the Special Specification or in the Bill of Quantities.

For clod-asphalt to be stockpiled, the bituminous binder shall be a slow-setting emulsion A3 or K3, as specified in the Special Specification or in the Bill of Quantities.

(b) Aggregate

Coarse aggregate (retained on a 4.75 mm sieve) shall consist of crushed stone produced from rock or boulders. The minimum size of rocks or boulders to be crushed shall be at least 4 times the maximum size of the crushed aggregate. The coarse aggregate shall be free form clay, silt, organic matter and other deleterious substances. The aggregate shall comply with the requirements given in the Table 13.25.

Table 13.25: Requirement of Aggregate

Aggregate Class	A	B
LAA Max.	25	30
ACV. Max	20	20
SSS Max.	12	12
FI Max	20	25

The fine aggregate (passing 4.75 mm sieve) shall be free from clay, silt, organic and other deleterious matter. Unless otherwise specified, it shall consist of at least 90 percent entirely crushed sand produced form stone having a Los Angles Abrasion of not more than 30. The Sand Equivalent of the fine aggregate shall be not less than 60 and the SSS not more than 112

The mixture of aggregate shall be within and approximately parallel to the grading envelope specified in the Table 13.26.

Table 13.26: Grading Envelop of Aggregate

Sieve Size (mm)	Percentage passing by weight
14.000	100
10.000	90-100
4.750	54-70
2.360	35-49
1.180	25-38
0.425	16-25
0.075	6-9

(c) Mineral Filler

The mineral filler shall consist of finely ground particles of limestone, hydrated lime, Ordinary Portland cement or other non-plastic mineral matter as specified in the Special Specification or in the Bill of Quantities. It shall be thoroughly dry and free form lumps. At least 75% (by weight) shall pass a 0.075 mm sieve and 100% shall pass a 0.425 mm sieve. It shall have a bulk density between 0.5 and 0.9 g/ml measured in accordance with BS 812-2.

(4) Requirements for Cold Asphalt

The mixture shall comply with requirements given in the Table 13.27:

Table 13.27: Requirement for Cold Asphalt

Description	Requirements
Marshall Stability 50 blows (N)	7,000
Flow Value (mm)	<4
Voids in total Mix (%)	2-4
Compression/Immersion Ratio	0.75

The proportion, by weight of total mix, of bitumen shall be stated in the Special Specification or in the Bill of Quantities. This shall be termed the nominal binder content. The binder content of the working/job mix shall be instructed by the Engineer following laboratory and site trials.

(5) Mixing and Laying Cold Asphalt

Cold asphalt generally shall be laid for surfacing, base, leveling and patching works.

The moisture content of the mixture shall be adjusted in the mixing plant to permit optimum compaction. The aggregate shall have a moisture content in the range 3% - 5% at the time the emulsion is added.

Cold asphalt shall be placed at ambient temperature and may be laid by grader, provided the Contractor can demonstrate in the site trials that the he can achieve the specified geometric tolerances with this method.

(6) Compaction

Rolling shall be carried out by a sequence of roller in such a manner that it will ensure the full specified compaction and at the same time it will provide a finished surface within the tolerance laid down in this Specification.

The average density of the cold asphalt after compaction shall not be less than 98% of the average density obtained from Marshall specimens (50 blows) made during laboratory trials on the mixture used for site trials. No individual density shall be below 95% of the average of the laboratory specimens.

(7) Testing

(a) Sampling

Prior to use the Contractor shall supply the Engineer with samples of all materials proposed to be used. The Contractor shall carry out all the specified tests as the Engineer may require to satisfy himself that the material and proportions satisfy this Specification. No material shall be used, nor job mix adopted until they are approved in writing by the Engineer.

(b) Process Control

The minimum frequency of testing for process control shall be as given in the Table 13.28

Table 13.28: Minimum Testing Frequency

Test	Minimum number of tests
AGGREGATE:	
Grading	One test for every 100 m^3 or part of it and in every change of source
Los Angeles Abrasion	One test for every 500 m^3 or part of it and in every change of source
Aggregate Crushing Value	One test for every 500 m^3 or part of it and in every change of source
Flakiness Index	One test for every 100 m^3 or part of it and in every change of source
SSS	One test for every 500 m^3 or part of it and in every change of source
Sand Equivalent	One test for every 500 m^3 or part of it and in every change of source
Quality of Filler	" " 50 tonnes " " "
EMULSION:	
Quality of Binder	***The Contractor shall produce certificates from the concemed all suppliers to the effect that all material supplied by them comply with the relevant Specifications.*** In addition, one set of tests for each 20,000 litres or part of it of supply required.

Water Content	One test for each 100 of mix or part of it.
Sieve Test	One test for each 100 of mix or part of it.
MIXTURE:	
Grading and bitumen content	One test for each 100 toones of mix or part of it.
Marshall stability, flow and voids	One test for each 100 toones of mix or part of it.
CONSTRUCTION TOLERANCES:	
Compaction	One test per 500 m^2 or part of it
Surface levels	Every 10 m or at close intervals
Smoothness	Every 50 m^2 or at close intervals.

(c) Routine Inspection and Testing

Routine inspection and testing shall be carried out by the Engineer to test the completed work for compliance with the dimensional tolerances, quality of material, density of compaction and any other requirements stated in this Specification.

Any material and workmanship that do not comply with the requirements specified, shall be replaced by material and workmanship complying with their respective Specification.

(8) Measurement

Cold asphalt shall be measured cubic metre calculated as the product of the length and the compacted cross-sectional area of the cold asphalt laid as per drawing or as instructed by the Engineer.

(9) Payment

The cold asphalt shall be paid as per contract unit rate which shall be the full and the final compensation for the cost of compliance of all requirements specified in Clause 1307 and 13011 in addition to those specified in Clause 112.

(10) Adjustment in Contract Unit Rate

Should there be any variation between the specified (nominal) rates of application of binder, sand and/or mineral filler and their respective rate of application actually used in the work as per the direction of the Engineer, the contract unit rate for asphalt concrete shall be adjusted as per contract unit rate of the respective material quoted by the Contractor for the purpose of this variation.

The varied cold asphalt shall be paid as per adjusted rate.

SECTION 1400-KERBS AND FOOTPATHS

SECTION 1400-KERBS AND FOOTPATHS

1401. CONCRETE KERBS

(1) Scope

This Clause covers the works for construction of kerbs in the central median and/or along the footpaths or separators.

(2) Materials

The kerbs shall be provided in cement concrete of grade M 20/20 in accordance with Section 2000. These shall be either precast concrete blocks or cast-in-situ concrete.

Cement sand mortar used for bedding and joint shall be in 1:3 ratio and shall comply with the Sub-clause 2502 (2).

(3) Laying

The kerbs shall be laid on either concrete or compacted sand-gravel as indicated in the Drawing. In the case of concrete, it shall consist of grade M 10/20 or m 10/40 (as defined in Section 2000) laid to the dimensions, lines and levels shown in the Drawing and well compacted by ramming o rother means. The foundation shall have a projection of 50 mm beyond the kerb in plan. Before laying the foundation of lean concrete, the base shall be leveled and slightly watered to make it damp.

In the case of a sand gravel it shall consist of a material approved by the Engineer having a property complying with Clause 1201. The kerb shall then be laid out and bedded on 12 mm thick cement sand mortar of 1:3 ratio.

(4) Tests and Standard of Acceptance

Concrete shall be tested in accordance with Section 2000 and shall meet the specified criteria.

All kerbs shall be laid true to the lines and levels shown on the Drawing or as instructed by the Engineer.

(5) Measurement

Concrete kerbs shall be measured in linear meter. Concrete and/or sand-gravel foundation shall be measured in cubic meters. Excavation for foundation shall not be measured. It is deemed included in the measurement of kerbs.

(6) Payment

The concrete kerbs measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 including cost for excavation and backfilling , if any, and all other incidental costs so as to complete the work as specified.

Concrete and/or sand-gravel foundation shall be paid for separately, as provided under respective Sections of these Specifications.

1402. CONCRETE/STONE FOOTHPATHS

(1) Scope

This Clause covers the works for construction of concrete/stone footpaths as specified on the Drawing.

(2) Materials

The footpaths shall be constructed with any of the following types as provided in the Bill of Quantities or shown on the Draiwng.

(a) Cast-in-situ cement concrete of grades M20/20 as per Section 2000.

(b) Pre-cast cement concrete blocks of grade M/20/20 as per Section 2000. Unless otherwise specified or ordered by the Engineer they shall be 50 mm thick of a uniform width of 600 mm and not less than 450 mm nor more than 900 mm in length.

(c) Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture and free from defects. The stones, when immersed in water for 24 hours, shall not absorb water by more than 5% of their dry weight when tested in accordance with IS:1124. The specific gravity of the stones shall be at least 2.55. The minimum thickness of the natural stone slab shall be 25 mm and minimum size shall be 300 mm x 300 mm.

Concrete and cement sand mortar shall meet the requirements specified in Section 2000 and Sub-clause 2502 (2) respectively. Granular subbase shall comply with Clause 1201. Bricks shall comply with the requirements of NS 1/2035. The class of the bricks shall be as specified in the Contract.

(3) Laying

The base shall be prepared and finished to the lines, levels and dimensions as indicated on the Drawing. Generally material for base shall be:

(a) 150 mm thick compacted granular base as per Clause 1201 or

(b) 30 mm thick concrete base of grade M 15/20 or

(c) flat brick flat soling base.

Precast Cement Concrete Blocks/Natural Stone Slabs

The block/slabs shall be set on a layer of average 12 mm thick 1:3 cement sand mortar laid on the prepared base in such a way that there is no rocking. The gaps between the block/slabs shall not be more than 12 mm and shall be filled with 1:3 cement sand mortar.

Cast-in-situ Cement Cocrete

Unless otherwise specified, the thickness of cement concrete shall be 50 mm. It shall be cast on the prepared base of specified size in staggered manner. Construction joints shall be provided as per Section 2000.

(4) Tests and Standard of Acceptance

Concrete shall be tested in accordance with Section 2000 and shall meet the specified criteria. Granular subbase shall be tested in accordance with Clause 1201 and shall meet the specified criteria. One set of test for specific gravity and water absorption (3 tests in a set) shall be carried for each source of stones and the results shall meet the specified criteria.

All footpaths shall be constructed true to the lines and levels shown on the Drawing or as instructed by the Engineer.

(5) Measurement

Concrete stone footpaths shall be measured in square meter. The area to be measured shall be between inside of kerbs. No measurement for excavation and providing base/subbase shall be made. It shall be deemed included in the measurement of concrete/stone footpaths.

(6) Payment

The quantities of concrete/stone footpaths measured as provided above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

1403. BRICK PAVING IN FOOTPATHS

(1) Scope

This Clause covers the works for construction of footpaths with bricks laid on edge as shown on the Drawing.

(2) Materials

Burnt clay brick shall comply with the requirements of NS 1/2035. The Class of the bricks to be used shall be as shown on the Drawing. They shall be free form cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when stuck.

(3) Laying Bricks on Edge

Bricks shall be laid on a sand bed at least 500 mm thick. In cases where two or more layers of bricks are used each layer shall be separated by a layer of sand of 25 mm thickness. Bricks shall be laid on edge in the pattern shown in the Drawing or specified in the contract. Each brick shall be laid separately and tamped firmly into place on the sand-bed. The top surface of the layer shall be smooth and even.

(4) Tests and Standard of Acceptance

Bricks shall be regularly tested for water absorption and compressive strength. The frequency of tests shall be minimum one test for every 10 cu.m. of bricks or part of it. The test results shall meet the specified criteria.

Brick be laid to the true lines and levels shown on the Drawing or instructed by the Engineer.

(5) Measurement

Brick shall be measured in square meter for the completed and accepted work. Excavation and sand bedding shall not be measured. They shall be deemed included in the measurement of the paving.

(6) Payment

The brick paving as measured above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

1404. BITUMINOUS FOOTPATHS

(1) Scope

This Clause covers laying hot/cold asphalt premix cover a primed base/subbase as shown in the Drawing.

(2) Materials

The stipulations contained in Section 1300 shall govern with regard to the scope and materials of prime coat and premix except that the binder content

(net bitumen) of the premix shall be 6% by weight of the mix. The type of the mix to be used shall be as described in the Bill of Quantities. The stipulations contained in Section 1200 shall govern with regard to the scope and materials for base/subbase.

(3) Laying

The base/subbase shall be prepared in accordance with Section 1200. A prime coat shall be applied at the rate of 0.75 litres per square meter conforming to clause 1301. Manual method or use of relatively small capacity equipment shall be also permitted. The premix shall be prepared in suitable plant approved by the Engineer. Rolling shall be done as per Clause 1308.

(4) Tests and Standard of Acceptance

Base/subbase, prime coat and asphalt premix shall be tested in accordance with the stipulations as provided under respective Clause of these Specifications. The test results shall meet the specified criteria.

(5) Measurement

Bituminous premix, prime coat and base/subbase shall be measured in square metres as per stipulations of Section 1300. Subbase/base shall be measured as per stipulations of Section 1200.

(6) Payment

Bituminous premix, prime coat and subbase/base shall be paid at the respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112.

1405. CYCLE TRACKS

(1) General

Cycle tracks shall be constructed in accordance with the relevant Clauses of Sections 100, 1200 and 1300.

The requirement of materials and workmanship used in the construction of cycle tracks shall conform to the requirements of relevant Sections/Clause as applicable.

Measurement and payment shall be as per the relevant Clauses or as specified in the Contract.

SECTION 1500- TRAFFIC SIGNS, ROAD MARKING, ROAD MARKER STONES AND DELINEATORS

SECTION 1500- TRAFFIC SIGNS, ROAD MARKING, ROAD MARKER STONES AND DELINEATORS

1501. PERMANENT TRAFFIC SIGNS

(1) Scope

This Clause covers the supply and erection of permanent road traffic signs along the roadside, over the carriageway and crossroads, at interchanges and at the locations indicated on the Drawing or as directed by the Engineer.

(2) Materials

(a) Mounting Posts

Mounting post shall be of either 50 mm internal diameter steel tube of "heavy" category or 78 mm by 38 mm C channel. Structural steel shall comply with the requirements of IS 2062. Steel tube shall comply with IS 1161. Posts constructed form wood or reinforced concrete shall not be accepted.

(b) Bolts, Nuts and Washers

Steel bolts and nuts shall conform to IS 1367. All steel bolts, nuts and washers shall have a hot-dip (galvanized) zinc coating.

(c) Back Support Frames

Unless otherwise specified sign plates shall be supplied with a back support frame of a size and design to avoid the plate being deformed due to wind pressure or manipulation by vandals. The frame shall be made of a steel angle riveted or bolted to sign plate and shall incorporate brackets to enable the sign plate to be bolted to the sign plate.

(d) Steel Plate

Steel plate shall be 2.00 mm thick and comply with the requirements of IS 1079. After any cutting, welding and punching has been completed all sharp edges shall be uniformly rounded off and smoothed down. All physically adhering contaminants shall be removed and then thoroughly cleaned.

(e) Aluminium Plate

Aluminium plates used for signs shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS: 736 – Material Designation 24345 or 19000 and shall be 2.00 thick unless otherwise specified. After any cutting, welding and punching has been

completed all sharp edges shall be uniformly rounded off and smoothed down. The plate shall be degreased either by acid or hot alkaline etching and all scale/dust removed to obtain a smooth and plain surface. After clearing , metal shall not be handled except by a device or clean canvas glove.

(f) Retro-Reflective Sheeting

The reflective sheeting shall be either "Engineer" Grade or High Intensity reflective sheeting, as specified in the contract. The retro-reflective sheeting shall be of the enclosed lens type consisting of microscopic lens elements embedded beneath the surface of smooth, flexible, transparent, waterproof plastic. The adhesive backing shall be either of pressure-sensitive aggressive tack type requiring no heat, solvent or other preparation for adhesion, or track-free adhesive activated by heat a Heat Lamp Vacuum Applicator in a manner specified by the sheeting manufacture. The adhesive shall form a durable bond to smooth, corrosion and weather-resistant surface of the sign plate such that it shall not be possible to remove the sign sheeting from the sign plate.

The reflective sheeting shall conform to the following requirements:

(i) The sheeting shall have high reflectivity normal to vehicle headlights dependent on the angle of incidence. The reflective material shall be sharp and glareless and directed towards the light source at an approved angle of incidence.

(ii) The surface of the sheeting shall be smooth and flexible. No cracking shall occur when bent. Reflective sheeting shall have high durability under all weather conditions, heat and moisture and be strongly fungus-resistant.

(iii) The sheeting shall not delaminate, blister, crack, peel and chip during the manufacturing process and during its service life.

(iv) The sheeting supplied shall be free from dirt, solid lumps, scales, ragged edges and non-uniformity of colour.

(v) The colour of the sheeting shall be even and free from any spots or loss of colour. The colour shall not fade under local weather conditions during its expected service life.

(vi) Colour of sheeting used must correspond to the colours of the sheeting supplied as samples.

(vii) The reflective surface of the sheeting shall be durable and remain sharp during its expected service life. Bad weather conditions such as rain, dew, etc, shall not reduce the reflectivity.

(viii) The reflective surface of the sheeting shall be easily cleaned with soap and water with no adverse effect on its reflectivity and durability when used on the roads.

(ix) The adhesive used on the backing of the sheeting shall have give a high quality bonding to clean, smooth and grease free aluminium or other sign plates approved by the sheeting manufacturer. The adhesive shall withstand the conditions without allowing the sheeting to peel.

(g) Paints

Zinc chromate primer shall comply with the requirements of IS: 2074. Other types of primer shall comply with NS 190/2045. Enamel paint shall comply with NS 112/2042.

(3) Protective Painting

(a) Steel Surfaces

The prepared surface shall be given two coats of a zinc chromate primer confirming to IS 2074. The first coat shall be applied within 12 hours in the case of wash-primed surfaces and within 4 hours, but before any oxidation of the surface takes place , in the case of abrasive blasted surfaces.

(b) Aluminium Surfaces

Part of the sign plate not covered by the sheeting, including the reverse of the plate shall be applied with protective paint, applied by either stove-enameling or powder-coating process.

(4) Signs

The regulatory, warning and information sign shall be of the standard as detailed in the Drawing or shown in the Traffic Signs Manual (latest publication) published by the Department of Roads. The colour, configuration, size and location of all traffic signs shall be in accordance with the same manual.

The sign shall be either reflectorised or non-reflectorised as shown in the Drawing or instructed by the Engineer.

(5) Manufacturing of Sign and Posts

(a) Non-reflective Sign Faces

Non-reflective sign faces shall be manufactured from steel plate.

The background shall be painted with air-brush technique. The legends, borders, symbols, designs, etc. shall be screen printed.

(b) Retro-reflective Sign Face

Retro-reflective sign faces shall be manufactured from aluminium plate.

The background, legend, borders, symbols, designs, etc. shall be made by applying cut-outs. All the sheeting, except in black, shall be retro-reflective.

(c) Size and Shape of Signs

The size and shape of the signs shall be manufactured in strict accordance with the details provided in the Traffic Sign Manual (latest publication).

Traffic sign faces shall be manufactured as one unit. Traffic signs which are too large to be transported as one unit may, with the approval of the Engineer, be manufactured in sections. The completed sections shall be assembled in the shop prior to delivery to ensure that all sections fit together properly and that the legends are correctly spaced and aligned. Joints in sign faces shall only be provided at locations and to details approved by the Engineer.

(d) Welding

All welding of steelwork shall be carried out in accordance with the standards laid down in Section 2200. Welding shall be done before painting.

(e) Metal Extrusions.

Metal extrusions for sign faces shall be joined together by rivets or bolts. They shall not be joined longitudinally but, if this connot be prevented without excessive waste, they shall be joined neatly and joints staggered. No sections shorter than 500 mm shall be used.

Where alumunium extrusion are to be faced with retro-reflective background material, it shall be pre-applied to individual sections before assembly with the material taken around the face edges of each extension for at least 10 mm. Retro-reflective material shall be heated to facilitate binding around edges without damaging the material. Unless otherwise instructed by the Engineer, letter across the joint between two extrusions shall be avoided.

(f) Galvanising

Where the galvanizing of structural steel plates, back support frames and posts are specified, it shall be done after welding. Where, however, this is not practicable, the steel sections shall be galvanized before assembly and then welded. All welds shall be thoroughly cleaned, loose material removed and dressed after which the welds shall be coated with two coats of an approved zinc-rich paint. Unless otherwise specificed in the contract, galvanized steel shall not require painting

Where details for the construction of sign faces, the framework of the sign faces and the attachment thereof to the supporting framework are not shown in the Drawing, the Contractor shall design these himself and submit the details to the Engineer for approval before manufacture.

(g) Posts

The total length of the post shall be determined in such a way that the bottom side of the sign is 1.75 m above the carriageway surface. The section of the post shall be as shown on the Drawing or as instructed by the Engineer.

(6) Painting

(a) Colours, Symbols and Legend

Paint colours, symbols, legend, size of letterings and borders used on road signs shall comply with the Traffic Sign Manual (latest publication).

(b) Preparation of Surfaces and Application of Paint

The preparation of surface and painting shall be carried out in a manner to ensure that they are free from rust and scale.

Structural steel for sign face supports and frame work shall be given a wire brush surface preparation and painted. Unless otherwise specified, all painting work shall be carried out in accordance with IS: 1477.

(c) Time of Painting

Painting shall not be carried out more than six months prior to erection.

(7) Storage

All sign faces shall be protected by an easily-removable liner after manufacture. The liner shall be removable by peeling without soaking in water or other solvent and shall be suitable for the type of material used as the sign plate.

All traffic signs or portions of traffic signs shall be carefully handled and stored in a weather-proof storeroom to prevent any permanent deformation or damage to painted surfaces.

Package for shipment shall be in accordance with commercially acceptable standard to prevent movement and chafing. Sign faces shall be protected from scratching, rubbing and other damages. Sign shall remain dry during shipment.

(8) Erection of Traffic Signs

(a) Position

Traffic signs shall be erected in the positions and in the manner as shown on the Drawing or instructed by the Engineer.

(b) Excavation and Backfilling

Excavation for the erection of traffic signs shall be made according to the dimensions shown on the Drawing.

Unless otherwise specified, the foundation for sign mounted on a single post shall be 300 mm x 300 mm and 300 mm deep. The foundation for signs mounted on two or more posts shall be 450 mm x 450 mm and 600 mm deep. The concrete shall be of grade M 10/40 as per Section 2000 of these Specifications. The upper surface of the concrete shall be neatly finished with sufficient fall to ensure proper drainage.

(c) Erection

Traffic signs shall be erected as shown on the Drawing or directed by the Engineer. During erection, the sign faces shall be firmly bolted and protected in order that no bucking or damage is caused during erection, or by the equipment used for erection. Posts to which traffic signs are to be fixed shall be vertical, and the undersides of traffic signs shall be horizontal after completion of erection.

(d) Field Welding

All welding done during erection shall comply with the requirements for welding during manufacture.

(e) On Site Painting

All painting done after erection shall comply with the requirements for painting during manufacture. All places where the painting work has been damaged before or during erection shall be made good by the Contractor at his own cost to the satisfaction of the Engineer.

(f) Time of Erection

Road traffic signs shall be erected immediately prior to the opening of the road to public traffic unless otherwise decided by the Engineer.

(9) Tests and Standard of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to the relevant Specifications and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

(10) Measurement

The measurement of permanent traffic signs shall be in numbers of each type of signs supplied and erected in accordance with these Specifications. Excavation, concrete for foundations and backfill shall not be measured. They are deemed included in the measurement of the traffic signs.

(11) Payment

The quantities measured as above shall be paid at the respective contract unit rates for each type of signs. The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of excavation, concrete for foundation, backfill and all other incidental work so as to complete the work as specified.

1502. ROAD MARKINGS

(1) Scope

This Clause covers the permanent marking of the road surface with white or yellow paint as indicated on the Drawing or instructed by the Engineer.

The colour, width and layout of road marking shall be in accordance with the Traffic Signs Manual (latest publication), Department of Roads.

(2) Materials

Paint shall comply with the requirements of NS 408/054 or BS 6044 (1987) or as specified in the Contract. If specified in the contract, the paint may also be reflectorised paint, in which case the paint shall be reflectorised by the addition of reflecting beads (ballotini). The ballotini shall comply with BS 6088:1981 (1993).

The paint shall be delivered to the site in sealed containers bearing the name of the manufacturer and the type of paint.

The viscosity of the paint shall be such that it can be applied without thinning. Under no circumstance thinning shall be allowed.

The colour to be used shall be bright white or yellow as shown on the Drawing or indicated in the DOR's Traffic Signs Manual (latest publication).

(3) Weather Limitations

Road marking paint shall not be applied to damp surfaces or when the relative humidity exceeds 80%, or at temperatures lower than 10o C, or when, in the opinion of the Engineer, wind strength is such that it may adversely affect the painting operations.

(4) Tools and Equipment Painting

The paint shall be applied by brush or machine. However, before ordering paint, the Contractor shall inform the manufacturer the proposed method of application of paint to ensure that correct type of paint is ordered.

(5) Surface Preparation

Road markings shall be applied to bituminous surfacing only after sufficient time has elapsed to ensure that damage shall not be caused to the painted surface by volatile substances evaporating from the bituminous surfacing. In no case shall road marking be applied until at least 48 hours after the completion of the surfacing or any longer period required by the Engineer, has expired.

Before the paint is applied, the surface shall be clean and dry and completely free form any soil grease, oil, acid or any other material which shall be detrimental to the bond between the paint and the surface. The portions of the surface where the paint is to be applied shall be properly cleaned by means of watering, brooming or compressed air.

(6) Setting out of Road Marking

The line or marks shall be set out by means of paint spots of the same colour as the proposed final lines and marks. These spot marks shall be at such

intervals as needed to ensure that the road marking can be accurately applied, and in no case they shall be more than 1.5 from each other.

After spotting, the positions of the proposed road markings such as dotted lines, starting and finishing points shall be indicated on the road. Pre-marking shall be approved by the Engineer prior to the commencement of any painting operations.

The positions and outlines of special markings shall be produced on the finished road in chalk and shall be approved by the Engineer before they are painted. The use of approved templates shall be permitted on the condition that the positioning of the marking is approved by the Engineer before painting is commenced.

(7) Application of Paint

Where the paint is applied by means of a machine, it shall be applied in one layer. Before the road marking machine is used on the permanent works, the satisfactory working of the machine shall be demonstrated on a suitable site which is not part of the permanent work. Adjustment to the machine operation shall be followed by further testing. Only when the machine has been correctly adjusted, and the use thereof is approved by the Engineer after testing, the machine may be used on the permanent work. The operator shall be experienced in the use of the machine.

After the machine itself has been satisfactorily adjusted, the rate of application shall be checked and adjusted, if necessary, before application on a large scale is commenced.

Where two or three lines are required next to each other, the lines shall be applied simultaneously by the same machine. The paint shall be stirred before application in accordance with the manufacturer's instructions. Where painting is done by hand, it shall be applied in two layers, and the second layer shall not be applied before the first layer has dried out completely. As most road marking paint reacts with the bitumen surface of the road, the paint shall be applied with only one stroke of the brush or roller at any one point on the road to prevent reaction with bitumen surface.

Ordinary road marking paint shall be applied at a nominal rate of 0.42 litre/sq.m. for painted old surface, and 0.75 letre/sq.m. for new surface, or as specified in the contract.

(8) Application of Retro-reflective Beads

Where retro-reflective paint is required by the contract, the retro-reflective glass beads shall be applied by means of a suitable machine immediately after the application of the paint in one continuous operation. The rate of application of the beads shall be 0.8 kg/litre paint or such other rate as is specified in the contract. Machine which apply the beads by means of

gravity only shall not be used. The beads shall be sprayed onto the paint layer.

(9) Tolerance Requirement

Road marking shall be constructed to an accuracy within the tolerance given below:

(a) Width

The width of the lines and other markings shall not deviate form the specified width by more than 5%.

(b) Position

The position of lines, letters, figures, arrows, and other marking shall not deviate from the true position specified by more than 20 mm.

(c) Alignment of Markings

The alignment of any edge or a longitudinal line shall not deviate from the true alignment by more than 10 mm in 15 m.

(d) Broken Lines

The length of segments of broken longitudinal lines shall not deviate form the specified length by more than 150 mm.

(10) Faulty Workmanship or Materials

If any material not complying with the requirement is delivered on the site or used in the works, or if any sub-standard work is carried out, such material or work shall be removed, replaced or repaired as required by the Engineer at the Contractor's own cost. Rejected road marking and paint which has been splashed or dripped on the surfacing, kerbs, structures or other such surfaces, shall be removed by the Contractor at his own cost, in such a way that the marking or split paint shall not show up again later.

(11) Protection

After the application of paint, the road markings shall be protected against damage by traffic or other causes. The Contractor is responsible at his own cost for the erection, placing and removal of all warning boards, flags, cones, barricades and other protective measures which may be necessary.

(12) Tests and Standard of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to these Specifications and shall be to the true lines, level and dimensions as indicated on the Drawing or as directed by the Engineer, subject to the tolerances as indicated in these Specifications.

(13) Measurement

The measurement of road marking shall be in linear meter for each type of marking.

(14) Payment

The quantities measured as provided above shall be paid at the respective contract unit rate for each type of marking signs which shall be the full and the final compensation to the Contractor as per Clause 112 for carrying out the work as specified in these Specifications.

1503. ROAD MARKER STONE

(1) Scope

The work covers the supply, painting, lettering and fixing of road marker stones and shall include.

(a) Standard (Kilometer) Marker Stones

(b) 5^{th} Kilometer Marker Stones

(c) Node Point Marker Stone

The dimensions and other details of each type of marker stones shall be in accordance with the details shown in the DOR's **"Departmental Policy Document - The Establishment of Road Marker Stones"** (latest publication).

(2) Materials

The marker stones shall be constructed of reinforced cement concrete of grade M 15/20 as per the requirement of Section 2000. The paint shall be of non-reflectorised type and shall confirm to NS 112-2042.

(3) Construction

(a) Marker Stone Information Details

Each marker stone shall contain following road reference and location information:

(a) Road Category Letter
(b) Road Number
(c) Road Link Number
(d) Distance in km from node point
(e) Distance to the next town or landmark
(f) The chainage form the start of the road

All the above details shall be shown as specified in the "Departmental Policy Document - The Establishment of Road Marker Stones" (latest publication). Colouring, size of letters and numerals and language shall also be I accordance with the same policy document.

(b) Placing and Painting of Marker Stones

The location of the marker stones shall be as shown on the Drawing. They shall be placed at right angles to the centre line of the carriageway. On embankments they shall be located on the edge of the roadway at least 0.5 m outside the road shoulder. Where there is no shoulder the marker stones shall be at least 1.5 m outside the road edge, if necessary on specially erected platforms. In cut sections they shall be fixed clear of the shoulders as well as the side drains.

Marker stones shall normally be placed on the left hand side of the road as one proceeds from East to West and from South to North. On divided roads with a centre median the marker stones shall be placed on the left hand side of the road in each direction of travel. In hilly areas, where the road has a valley on one side and a hill slope on other, the marker stones shall be placed on the valley side of the road.

Marker stones posts shall be bedded into the ground with concrete foundation of grade M 10/40 as shown in the Drawing. Marker stones shall be applied with a coat of primer and two coats of enamel paint.

(4) Tests and Standard of Acceptance

The material shall be tested in accordance with the relevant standard specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to these Specification and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

(5) Measurement

Each type of road marker stones shall be measured in number. Excavation, concrete foundation and backfill shall not be measured. They are deemed included in the measurement of marker stones.

(6) Payment

The road marker stones measured as provided above shall be paid at the respective contract unit rate for each type of stone which shall be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of excavation, backfilling concrete foundations and all other incidental works so as to complete the work as specified.

1504. DELINEATOR POSTS

(1) Scope

The work covers supplying and fixing of delineator posts. The design and painting of the posts shall be in accordance with the Traffic Sign Manual (latest publication).

(2) Materials

The delineator posts shall be constructed of reinforced concrete of grade and M 20/20 in accordance with Section 2000 or as shown in the Drawing. Paint shall be non-reflectorised paint and shall be in accordance with NS 112-2042. Primer shall comply with NS 190/2045.

(3) Manufacturing

Posts shall be manufactured to the dimension shown on the Drawing or as per Traffic Signs Manual (latest publication). Forms shall be smooth and have accurate dimension. The concrete mix shall be placed in the forms and vibrated. The posts shall reinforced as detailed in the Drawing.

The post shall be true to the shape, smooth and without honeycombing or other blemishes. The posts shall be provided with recess.

(4) Erection and Painting

Posts shall be erected after the completion of pavement surfacing. Holes shall be excavated at a distance of 600 mm from the road edge or at locations instructed by the Engineer. The posts shall be placed vertically and square to the road center line. Backfilling shall be compacted in layers not exceeding 150 mm thick right from the bottom of the hole.

The posts shall be applied with a coat of white cement primer and two coats of synthetic enamel paint. The paint shall be applied in 200 mm wide alternate strips of white and black starting from the top.

The posts shall be painted immediately after placing. If specified in the contract or shown in the Drawing the posts shall then be provided with 100 mm x 80 mm reflective element.

(5) Tests and Standard of Acceptance

The material shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to these Specification and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

(6) Measurement

Each type of posts (with or without reflective element) shall be measured in number. Excavation, preparation of foundation and backfill shall not be measured. They are deemed included in the measurement of posts.

(7) Payment

Delineator posts measured as provided above shall be paid at the contract unit rate for each type of post. The contract unit rate shall be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of excavation, backfill, painting reflecting elements (where specified) including all other incidental costs so as to complete the work as specified.

SECTION 1600 – PILING FOR STRUCTURES

SECTION 1600 – PILING FOR STRUCTURES

1601. SCOPE

This section covers the works connected with various types of piles required for structures.

1602. GENERAL

The requirements contained in this specification and in the Drawing are the minimum requirements. Strict compliance with these minimum requirements shall not relieve the Contractor of the responsibility of adopting whatever additional measures which may be necessary to ensure the completion of the work to the satisfaction of the Engineer. Unless contracted hereunder, the provision of IRC: 78-1983 shall be strictly followed.

In addition to submitting the records required under Sub-clause 1607 (3) the Contractor shall report immediately to the Engineer any circumstances which indicate that the ground conditions differ from those expected by the Contractor from his interpretation of the soil survey so as to materially affect the bearing capacity of the piles.

1603. TYPE OF PILES

Based on materials piles may be

(1) Timber piles
(2) Steel piles
(3) Concrete piles of normal or pre-stressed concrete

Based on method of construction piles may be

(1) Driven piles
(2) Bored/Drilled and cast-in-situ piles.

Timber, steel and pre-cast concrete piles are of driven type. Piles may be of solid or hollow Section or steel cased piles filled with concrete. They may be of circular, square, hexagonal, H, I, or Z Section as applicable.

Timber and steel/steel sheet piles shall comply with their Specifications as provided in the contract.

1604. PENETRATION AND BEARING VALUE

The bearing values of the piles shown on the Drawing or indicated in the contract are the minimum bearing values to which must be driven or installed. The driving or installation of the piles shall continue until the estimated penetration and set is

reached or until the pile has been driven to substantial refusal or to a penetration and set satisfactory to the Engineer. When water jets are used the bearing capacity of a pile shall be determined from the results of driving with the hammer after the water jets have been withdrawn. The bearing value and set for the purpose of this Clause shall be calculated from the appropriate formula as given in IS 2911 or such other criteria as shall be indicated or described in the contract.

1605. EXCAVATION IN CUTTING

Specification for pre-cast pre-stressed concrete piles shall conform to those contained in Clause 8 of IS:2911 (part 1 Section 3), if not covered by Sections 1800, 2000 and 2100.

Every pile shall be marked with the date of casting and an identification number. Pre-stressed piles shall also be marked with the pre-stressing force applied.

Pre-cast concrete piles shall be of the size and shape as shown on the Drawing. If a square Section is employed, the corners shall be chambered at least 25 mm unless otherwise specified on the Drawing. The length of pile shall not normally exceed 25 metres. However, where special equipments for handling and installation are available to the satisfaction of the Engineer, longer length shall be permitted.

Piles shall be cast with a driving point for hard driving and shall be cat with a metal shoe approved by the Engineer

1606. DELIVERY, HANDLING AND STORAGE OF PILES

(1) Number and Length of Piles

When testing of piles are specified in the contract, the pile lengths as shown on the Drawing or described in the contract shall be used for tendering purpose only. The number, Section and length of piles as specified shall be subject to change. No piles except test piles, shall be ordered, delivered to site or manufactured on site for any units of a structure until the Engineer has determined from the results of the driving of the test pile. When the test piles are not specified, the number and lengths of piles to be ordered, delivered to site or manufactured on site shall be as specified in the contract.

(2) Handling and Storage

All piles shall be handled, transported and stored in such a way that they shall not be damaged. The use of can hooks, lifting tongs or other pointer tools shall not be permitted. Precast concrete piles shall be supported at the indicated pickup points and shall only be lifted with bridles or slings attached at such pickup points. If no pickup points are indicated they shall be assumed to be at a distance of 0.207 times the length of pile from each

end for two points lifts. For three points lift it shall be at a distance of 0.145 times length of pile from each end with the middle point being at the centre. The Contractor shall be responsible for any damage caused by handling or storage.

1607. DRIVING EQUIPMENT

(1) Pile Driving Frames on leads

Leads shall be required for all types of hammers. Leads shall be so constructed as to allow free movement of the hammer and shall be rigid enough to hold the pile in correct alignment during the driving operation. The leads should be of such length, where practicable, that the use of followers shall not be necessary. The use of hanging leads, guyed leads or other leads shall be subject to the approved of the Engineer, whose approval, if given, shall not relieve the Contractor of the responsibility of driving the piles to the placing and vertically tolerances allowed in the contract.

(2) Pilling Hammers

Pile Hammers, other than drop hammers shall be of approved steam, air or diesel hammers, that develop sufficient energy per blow to drive the piles at a penetration rate of not less than 5 mm per blow at the required bearing value. Steam or air hammers shall be with boiler or air capacity at least equal to that specified by the manufacturers of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gauge. The value, mechanism and other parts of the hammers shall be maintained in good condition and working order so that the length of stroke and number of blows per minute for which the hammer is designed shall be obtained. Inefficient steam, air, or diesel hammers shall be removed from the site. As a general guide the size of the hammer normally required for steel piles shall be one which develops approximately 1100 kg metres energy per blow. Pre-cast concrete piles and steel shell for cast-in-situ piles longer than 15 metres shall normally require a hammer which develops 1725 kg metres energy per blow. Drop hammers shall in no case weigh less than the combined weight of the pile, dolly and helmet. The Contractor shall, upon request, furnish the Engineer with evidence of the weight of the drop hammer as he requires.

(3) Pile Driving Helmets and Dollys

(a) For Steel Piles

Whether driving is done with a gravity or a mechanical hammer, a special driving helmet shall be used. It shall be recessed to fit closely around and have a full bearing on the pile head. For Gravity Hammers it shall have a dolly of suitable material on the upper side.

(b) For Pre-cast Concrete Piles

A driving helmet shall be used which fits closely over the head of the pile. A cushion block of coir or wood shall be used between the pile head and the helmet and the helmet shall have a dolly of suitable material on the upper side.

(c) Shells for cast in-situ piles, if not driven with an internal mandrel shall be driven with a helmet as for steel piles. Shells driven with an internal mandrel shall have a cushion of low water cement ratio green concrete placed in the bottom of the shell. Fresh green concrete shall be added to the cushion after every 30 minutes of driving or after any break in driving of longer than 30 minutes.

(4) Water Tests

The jet or jets shall be freely eroding the material under the pile. The nozzle of each jet shall have a minimum diameter of 19 mm and shall generally be circular. The pump supplying the water shall be of such size & type that it shall maintain a water pressure of at least 9 kg/cm_ at the orifice of each nozzle.

1608. PILE DRIVING

(1) General

The Contractor shall notify the Engineer at least 24 hours before beginning any pile driving operations and no piles shall be driven unless the Engineer or his Inspector is present. Before any foundation piles are driven in any unit including test piles, the excavation shall be made, approximately, to the planned footing level. Piles to be driven through embankments over 1.5 m in depth constructed by the Contractor shall be driven in holes excavated through the embankment of dimensions not less than the pile dimensions plus 15 mm. After driving, the space around the pile shall be filled with dry sand or single size gravel. During pile driving operations the water level in the excavation shall be kept below the top of the pile. Under water pile driving shall only be permitted when the contract calls for a concrete seal foundation. In such cases, the piles shall be driven by a mechanical hammer equipped to drive when submerged. When the top of the hammer is submerged during driving, it shall be equipped with accurate measuring detachable measuring rods, for the purpose of recording pile penetration. Care shall be taken to obtain accurate location and spacing of the pilling. In all cases of under water driving, the equipment and method to be used shall be approved by the Engineer in writing. When satisfactory penetration of piles cannot be obtained without damage to the pile from driving, and the character of the soil is considered suitable, the Contractor may with the Engineer's approval use water jets in sufficient numbers to obtain the desired penetration. Before the desired penetration is reached the jets shall

be withdrawn and the pile shall be allowed the jetting or the provision of jetting equipment. Water jets shall not be used as an aid for driving steel piling. The driving of piles by means of followers shall be avoided if practicable and shall only be done with the written permission of the Engineer, who may require that one pile from any group of 10 or less shall be a long pile driven without a follower to determine the average bearing power of the group. Sawing or cutting the body of a pile to assist in springing it to proper location shall not be permitted. If a pile vibrates excessively or shows signs of buckling during it shall be braced or guyed as directed by the Engineer. Broken, spilt or wrongly treated piles shall not be measured for payment and if required by the Engineer they shall be completely withdrawn and replaced by satisfactory piles.

(2) Installation

Installation of piles shall be carried out in accordance with the pile layout Drawing or as directed by the Engineer.

The Engineer shall decide the sequence of the group of piles that the Contractor should undertake for installation and shall follow this sequence. In a group the installation shall proceed from those on the centre of the group towards those on the periphery.

(3) Temporary

The Contractor shall ensure that free standing piles are temporarily braced on stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that no damage resulting from oscillation, vibration or movement of any free-standing pile length can occur.

(4) Tolerance in Driving

During driving, the piles shall not deviate from the vertical or the specified rake (in the case of raker piles) by more than 40 mm per metre of pile length, and after driving the centre of the pile at cut-off level, shall be not more than 150 mm from its planned location.

1609. CUTTING AND LENGTHENING OF PILES

(1) Pre-cast Concrete Piles

Concrete piles shall be cut off at such level that they shall extend into the cap or footing as indicated in the Drawing. If piles are to be lengthened the main or splicing reinforcement shall be stripped of concrete for the distance necessary to effect a lapped reinforcement splice in accordance with Clause 2013. Alternatively, subject to the Engineer's approval, the reinforcement shall be exposed for a minimum of 250 mm and the extension reinforcement butt welded to the original reinforcement is at least equal to the 28 days

cube strength of the concrete in the original pile and approval of the Engineer to resume driving has been obtained. In cases, where a substantial number of pile extensions are expected, the Contractor may propose special extension methods and procedures. In such cases, the Contractor shall submit full details of the method and procedure proposed and carry out such tests as the Engineer may require to substantiate the soundness, strength and durability of the extended piles and their suitability to fulfill their function adequately.

(2) Steel Piles and Steel Cast-in-situ Shells

Piles shall be cut off at the appropriate level for incorporation of the footing or cap as shown in the Drawing. When driven to cut-off level without damage to the head a tolerance of 25 mm from the true cut off level shall be allowed.

1610. PILE HEAVE

The Contractor shall take and maintain records of the levels of every pile immediately after driving in accordance with the requirements of the Engineer. After all piles in the group have been completed, the levels shall be checked to determine whether any of the piles has heaved. Such heaved pile shall be re-driven and pile shall not be considered complete until all heaved piles have been re-driven as directed by the Engineer.

1611. CAST-IN-SITU PILES

Cast in situ concrete piles may be either installed by marking a bore into the ground by removal of material or by driving a metal casing with a shoe at the tip and displacing the material laterally. The two types of piles are termed as bored and cast-in-situ piles and driven shell and cast-in-situ piles respectively.

1612. BORED AND CAST IN-SITU PILES

(1) Steel Casing

When permanent steel casing is shown on the Drawing, the minimum thickness shall be 10 mm. The minimum length shall be from 100 mm above the bottom of the pile cap to 5 meter under the river bed or into the firm strata. Joints between casing shall be approved by the Engineer. The casing shall be handled and stored in a manner that shall prevent bucking and other deformation as well as accumulation of dirt, oil and paint.

(2) Concrete

The concrete shall conform to the requirements specified in Section 2000.

Concrete placed under water or drilling mud by tremie shall have a cement content of not less than 350 kg/m3. The density and consistency of the concrete shall conform to the tremie casting method. Sufficient workability (slump) of all the concrete during the casting and handling of casing including reasonably calculated delays, shall be secured by a design mix. Necessary retarders and plasticizers shall be tested by trial mixes prior to the pile construction.

All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured on the trial mixes.

(3) Reinforcement

The reinforcement shall conform to Section 2000.

(4) Drilling Fluid

The following requirements shall be complied with, if benotonite mud is used to stabilize the boreholes:

(a) Supply

A certificate shall be obtained by the Contractor showing the properties of the consignment delivered to the site. This certificate shall be made available to the Engineer for his approval.

The Contractor shall get approval of the Engineer for any other material proposed by him for the drilling fluid.

(b) Mixing

Bentonite and any other material shall be mixed thoroughly with clean water to make a suspension which shall maintain the stability of the pile excavation for the period necessary to place concrete and complete the construction.

(c) Tests

The frequency of testing drilling fluid along with method and procedure of sampling shall be proposed by the Contractor for approved by the Engineer prior to the commencement of the work. The frequency may subsequently be varied as required, depending on the consistency of the result obtained.

The Contractor shall supply all equipments and experienced operators required to carry out tests on the drilling mud. No additional payment shall be made for these tests which shall be considered as an essential part of the drilling operations.

(5) Construction Methods

The Contractors shall demonstrate to the satisfaction of the Engineer that his proposed construction method for the pile do not weaken the pile shaft by contamination of the concrete by sectional reduction, by washing out of cement, by breaking during pulling of temporary casing or in any other way including the construction of neighbouring piles.

(a) Procedure

The following construction procedure shall be followed:

(i) If permanent steel casings is not specified, a sufficient length of temporary steel casing shall be used to stabilize the upper part of the borehole.

(ii) Boring and excavation inside the steel casing shall be carried down to the casing toe level or to a level approved by the Engineer. The excavation shall be continue to final pile tip level using either temporary casing under water or using drilling mud. The fluid level inside casing shall at all times be at least 2 metres higher than outside the casings.

(iii) All mud or sedimentation from the bottom of borehole shall be cleaned up.

(iv) Reinforcement cage, inspection pipes etc. shall be placed shown on the drawing or instructed by the Engineer.

(v) Concreting underwater or drilling fluid shall be carried out continuously using tremie method.

(vi) Withdrawing of the temporary boring casing to the instructed level shall be carried out concurrently with concreting.

(vii) After hardening, the top Section of the concrete pile shall be broken to reach sound concrete in the pile.

(b) Approval of Construction Method

The Contractor shall describe the construction method he proposes, including name of proposed Sub-contractor (if any), information on boring equipment, materials, method of boring and quality control.

After the contract has been awarded the Contractor shall prepare a detailed programme and establish for the pile construction. The detailed programme shall contain all required information on materials, equipment, methods of work etc., and be approved in writing by the Engineer. Such approval shall not however relieve the Contractor of

his responsibilities for pile construction. The import of any boring equipment or materials by the Contractor, before he has receive the Engineer's approval of proposed construction methods, shall be at the Contractor's risk.

The Contractor shall check the casing position for each pile during and immediately after placing the casing, and agree it with the Engineer.

(c) Tolerances

The Centre of the complete pile at cut off level shall not deviate more than 100 mm from the theoretically correct position shown on the drawing. The inclination of the pile shall not deviate more than 1:100 from vertical. The Contractor shall provide suitable equipement such as inverted pendulum, to check the vertically of the boreholes at intervals during drilling and prior to concreting.

(6) Boring

(a) Methods

Methods of excavation shall be proposed by the Contractor for approval of the Engineer. Water or air jetting for boring of the piles shall not be allowed.

(b) Boring near recently cast Piles

Piles shall not be bored so close to other piles which are cast and contain workable or unset concrete likely to flow.

Boring and excavation for a pile shall not commence until 24 hours after completion of any pile within a radius of 6 metres center to center.

(7) Temporary Casing

Temporary casing of approved quality or an approved alternative method shall be used to maintain stability of pile excavation which might otherwise collapse.

(8) Stability of Pile Excavation using Drilling Fluid

Pile through water and/or soft upper soil layers shall be provided with permanent steel casing if shown in the Drawing.

The pile boring shall be carried out using temporary steel casing bored in pile toe, to the level of side fall or to a level approved by the Engineer. Before concreting the temporary casing shall be gradually withdrawn. Under certain circumstances the Contractor may permitted to bore all part or

the pile without casing under water or using drilling fluid to stabilize the borehole.

Where borehole is formed without casing under water or using drilling fluid for maintaining the stability of a boring, the level of the water or fluid in the excavation shall be maintained so that the water or fluid pressure always exceeds the pressure exerted by the soils and external ground water. The water or fluid level shall be maintained at a level not less than 2 meters above the level of the river water level or any artesian pressure level.

In the event of a rapid loss of water or bentonite suspension from the pile excavation, the excavation shall be backfilled without delay and the instruction of the Engineer shall be obtained before excavation at that location is resumed.

(9) Pumping

Pumping from the borehole shall not be permitted unless a casing has been placed into a stable stratum which prevents the flow of water from other strata in significant quantities into the boring, or unless it can be shown that pumping shall not have a detrimental effect on the surrounding soil or property.

(10) Removal of Obstruction

Where boulder or other obstruction render it impossible to bore the pile, excavation operation inside pile casing as directed by Engineer shall be carried out to remove obstructions. The Contractor shall be reimbursed fro such operation only when the largest dimension of the obstruction exceeds 200 mm and the obstruction is found more than 2 meters below river bed.

Disturbed and/or undisturbed samples of the soils from boreholes shall be submitted to the Engineer. The contractor shall allow for carrying out sampling and tests to check soil strength including field tests like SPT tests as required by the Engineer.

(11) Final Toe Level of Piles

The final toe level shall be as indicated on the drawing or as instructed by Engineer after due consideration of the Contractor's proposals, boring logs and test results.

The final toe level of other piles may subsequently be altered according to the results of the tests loading detail in the Section.

(12) Inspection and Cleaning bottom of Excavation

The time between final excavation including bottom cleaning and the start of concreting shall be reduced as much as possible and in any case shall not exceed 6 hours.

The cleaning shall be done by an approved method. Before cleaning bottom of every excavation, notice shall be given to the Engineer. The Contractor shall show, to the satisfaction of the Engineer, that the bottom of the excavation is clean.

If boring without casing, the diameter of the borehole for a representative number of piles shall be measured by caliper to the placing of concrete.

These measurements shall be done by the Contractor using approved equipment and no reimbursement shall be made for this.

(13) Placing Reinforcement

The reinforcement shall be placed as indicated on the Drawing. Reinforcement in the form of a cage shall be assembled with additional support, such as spreaders forks and lacings necessary to form a rigid cage. Hoops, links or helical reinforcement shall fit closely around the main longitudinal bars and be bound to them by approved wire, the ends of which shall be turned into the interior of the pile or pour. Reinforcement shall be placed and maintained in position. The cover to all reinforcement shall be not less than 75 mm.

Joints in longitudinal bars in piles with tension (for instance for test loading) shall be carried out by welding unless another method has been approved by the Engineer.

(14) Placing Concrete

(a) Approval from the Engineer

No concreting shall take place before the bottom of excavation has been cleaned. The Contractor shall get borehole inspected and obtain approval in writing from the Engineer.

(b) General Requirements

While placing concrete, these requirements shall be complied with

(i) The method of placing and workability of the concrete shall be such that a continuous monolithic concrete shaft of the full cross Section is formed.

(ii) The concrete shall be placed continuously and without such interruption as would allow the previously placed batch to have hardened. In this respect the Contractor shall submit details of his contingency plans, standby plants etc. to be utilized in the event of an equipment failure.

(iii) The use of pumped concrete and the methods in its use shall be approved.

(iv) The Contractor shall take precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No spoil, liquid or other foreign matter shall be allowed to contaminate the concrete.

(v) Concrete to be placed under water or chilly fluid shall be placed by tremie and shall not be discharged freely into the water or drilling fluid.

(vi) Before concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring. The Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the hole.

(vii) A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, the placing of concrete shall not proceed. In this event the Contractor shall modify the mud quality. The concrete shall be a rich and coherent mix of high workability in accordance with the requirement of Section 2000.

(viii) The concrete shall be placed in such a manner that segregation does not occur.

(ix) During and after concreting damage to the concrete from pumping and dewatering operations shall be avoided.

(x) The hopper and pipe of the tremie shall be clean and watering throughout. The pipe shall extend to the base of the boring. A sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the pipe of he tremie and the water of drilling fluid. At all times the pipe shall penetrate the concrete placed and shall not be withdrawn from the concrete until completion of concreting. The bottom of the tremie pipe shall be kept at least 1.5 metres under the surface of concrete. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that

the pressure from it exceeds that from the water or drilling fluid. The internal diameter of the pipe tremie shall not be less than 150 mm for concrete made with 20 mm aggregate and not less than 200 mm for concrete made with 40 mm aggregate. It shall be so designed that external projection are minimized, allowing the tremie to pass through reinforcing cages without causing damage. The internal face to the pipe of the tremie shall be free from projections.

(xi) The Contractor shall maintain a continuous record of the volume of concrete used and the level of the concrete in the pipe. Any deviations form the theoretical, or expected, volume/level relationship shall be immediately reported to the Engineer.

(c) Workability of Concrete

Slump measured at the time of discharge into the pile shall be in accordance with that given in the Table 16.1.

Table 16.1: Slump of Concrete for Pile Boring

Pilling mix workability	Slump		Typical conditions of use
	Minimum mm	Range mm	
A	75	75-150	Placed into water free unlined or permanently lined bore of 600 mm diameter or over where casting level lies below temporary casting: reinforcement widely spaced bearing ample room for free movement of concrete between bars.
B	100	100-200	Where reinforcement is not spaced widely where cut off level of concrete is within temporary casing where pile bore is water free and the diameter is less than 600 mm.
C	150	150	Where concrete is to be placed by tremie under water or chilly mud or by pumping.

(15) Extraction of Temporary Casing

(a) Workability of Concrete

Temporary casing shall be extracted while the concrete within remains sufficient workable to ensure that the concrete is no lifted.

(b) Concrete Level

When the casing is being extracted a sufficient quantity of concrete shall be maintained in it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in Section nor contaminated. The toe of the temporary casing shall be kept at a minimum of 2 metres under the outlet of the tremie.

Adequate precautions shall be taken in all cases where excess head of water or drilling fluid exists.

The pile shall be concreted with certain over height to allow for chiseling off the top concrete down to sound hard concrete.

(c) Vibrating Extractors

The use of vibrating casing extractors shall be permitted for the extraction of the casing.

(d) Reinforcement Cage

During concreting and puling casing, the reinforcement cage shall be secured against uplift the top shall be kept under close monitoring.

(e) Supervision

The execution of the pile concreting shall be supervised by a qualified and experienced person of the Contractor, who shall keep records on the relation between quantity of concrete used, level of concrete and withdrawal of casing.

(16) Measures Incase of Rejected Piles.

If any pile is found unsatisfactory in the opinion of the Engineer for utilization in the structure, it shall be cut off below the pile cap, if so ordered by the Engineer. The piles shall be replaced as directed by the Engineer. All extra expenses shall be borne by the Contractor and the payment shall be made for original piles only considering that no replacement piles are bored.

When by test, the safe allowable bearing value of any pile is found to be less than the design load, longer piles or additional piles shall be installed as ordered in writing by the Engineer.

1613. DRIVEN SHELL CAST IN-SITU PILES

(1) Shells for Cast In-Situ Piles

Steel shell may be of any type which has a tip diameter of not less than 300 mm, a thickness of not less than 3 mm, and a top diameter not less than that required in the contract, which shall satisfactorily withstand the required driving without distortion or damage to the pile, and which can be filled with concrete for it's entire length without placing concrete in or under water. The capacity of the pile frame shall be selected after considering the size and weight of the casing tube to be handled, the location of the work and the hardness of driving. Detachable shoes used with the temporary steel casing shall be cast iron, double rimmed and of requisite strength, standard and sizes to be used with the respective steel casing. The shoe shall be coaxial with the steel casing. However, mild steel pile shoes also shall be accepted. They should have been fabricated out of mild steel plates conforming to IS 2062. Casings distorted from the true and uniform shape, whether caused by driving or earth and water pressure resulting in a reduction of the cross sectional area of the pile in excess of 10 percent shall not be used in the work.

Steel shells for concrete in-situ piles which protruded above ground or bed level shall be as shown on the Drawing, specified in the contract or ordered by the Engineer.

(2) Construction

Before commencement of work the Contractor shall submit to the Engineer construction method and details of driving equipment for his approval.

(a) Driving of steel Casing:

Steel casings shall be driven as per layout plan shown on the drawing or as directed by the Engineer. Sequence of driving steel casing in pile group shall be as agreed by the Engineer.

After commencement of driving all time, prior to the placing of concrete in the driven shells or casings, the Contractor shall provide a suitable light for the inspection of the shell or casing throughout its length. Any improperly driven, broken or defective shell shall be replaced, or an additional pile shall be driven at the expense of the Contractor. Any reduction in the cross-sectional area in casings or shells in excess of 15% shall be cause for rejection. The insertion of internal casing to remedy defects shall not be permitted. No concrete shall be placed in cast-in-situ piles until all driving within a radius of 6.0 m has been completed, nor until the shells, for any area sub-structure unit or bent, have been completely driven. If this cannot be done, all driving within a 6.0 m distance shall be discontinued until the concrete in the last pile cast is at least 7 days old.

(b) Cleaning and Inspection

Before placing reinforcement accumulation of water or debris in the shells shall be removed and thoroughly inspected throughout its length. It shall be ensure that reduction of the Section, if any, shall not be excess of 15% of the specified Section and the toe level shall be the same as shown on the drawing or directed by the Engineer.

(c) Placing of Reinforcement

The reinforcement shall conform to the requirements of Section 2000.

The reinforcement shall be prepared and placed as described in Clause 1612.

(d) Placing of Concrete

The piles shall be cast with the concrete using design mix as specified in the contract.

Care shall be taken to preserve correct cover and alignment of reinforcement throughout the whole operations of placing the concrete.

Before placement of concrete care shall be taken to ensure that the inside of the casing is free from sludge or any foreign mater. Water inside the casing, if any, shall be removed by bailing or pumping. Where this is not possible, the under water correcting shall be done with necessary precautions after receiving the specific approval of the Engineer.

The concrete shall be placed to fill the entire volume of the casing without the formation of voids caused by entrapped air. Proper compaction shall be employed to obtain a dense and high quality concrete. The concrete shall be vibrated immediately after placing each lift and lifts shall not exceed 1.25 m in height. The filling of piles in conjunction with the placing of concrete in the footing shall not be permitted. The volume of concrete placed shall be observed in the case of few piles initially cast and the average figure obtained shall be used to check, whether there is any deviations in the volume of concrete placed for the subsequent piles.

Consistency of concrete to be used for cast-in-situ piles shall be suitable to the method of installation of piles. Concrete shall be so designed or chosen as to have a homogeneous mix having a slump/workability consistent with the method of concreting under the given condition of pile driving. The minimum slump shall be 100 mm when the concrete in the pile is not compacted. The slump shall not exceed 180 mm. in any case. The Contractor shall submit mix design report including calculations and carry out adequate number of tests to ensure the minimum strength in accordance with the Specifications.

The top of the pile shall be brought above the required finished level and any defective concrete removed to ensure satisfactory bonding of the pile head to the substructure.

Withdrawal of casing shall be carried out in stages and utmost care shall be exercised in maintaining an adequate head of concrete above the bottom of casing at each stage of withdrawal so as to prevent the inflow of soil and water into the casing.

(e) Miscellaneous

The requirements for placing reinforcements and concrete, workability of concrete extraction of temporary casing, tolerance, etc. as described in Clause 1612 shall be met with, as applicable.

1614. PILE TESTS

(1) Test Piles

The Contractor shall furnish test piles of the type, number and length specified in the contract. Generally the test piles shall be located so as to permit their use in the finished structure and they shall be installed at the positions shown on the Drawing or specified in the contract.

In order to obtain the best possible data from the test pilling the Engineer shall have the right to change test piles from their planned location to any other location in that group or any other group of the structure without any adjustment in the Contract Prices.

The installation shall be done using the same equipment as is to be used for installing the other piles in the works. The Contractor shall co-operate with and assist the Engineer in obtaining data for bearing for the full length of the installation.

When using driven piles in soft or plastic soils, the Engineer may require test piles to be re-driven. In such cases the driving shall be stopped at a point when the top of the pile is 600 mm to 1500 mm above cut off level and driving shall be resumed after a minimum of 24 hours.

(2) Loading Tests

Loading tests shall be made on those piles shown in the Drawing or ordered by the Engineer. All labour, material, equipment and attendance required to complete the tests shall be furnished by the Contractor.

The piles shall be tested as follows:

(a) The test load shall generally by 200% shown of the bearing required in the contract and be applied by a method approved by the Engineer. It shall be measured within an accuracy of plus or minus 2%. Settlements shall be measured within an accuracy of plus or minus 0.25 mm.

(b) The test load shall be applied in the increments as specified or approved by the Engineer. These shall generally be those recommended in IS 2911.

(c) The load after each increment shall be kept constant until the rate of settlement does not exceed 0.25 mm per hour.

(d) The value of settlement shall be recoded before the next increase of load.

(e) The full test load shall be maintained for 48 hours and the total settlement shall be recorded.

(f) The load shall be reduced in decrements equal to the increments with which it was applied.

(g) The load after each reduction shall be kept constant until the rate of recovery does not exceed 0.25 mm per hour.

(h) The amount of recovery shall be recorded before the next decrease of the load.

(i) The Contractor shall, with 24 hours of the completion of the test, submit to the Engineer for each pile tested, graphs showing;

(i) Load plotted against settlement and time

(ii) Settlement and recovery plotted against load.

(j) The settlement of the pile under the test load and recovery of the pile after the removal of the load shall be within the limits required in the contract or ordered by the Engineer.

(3) Other Requirements of Loading Tests

(a) A load test shall consist of the application of a load equal to twice the specified bearing capacity or as otherwise provided for herein or as directed by the Engineer. Unless otherwise permitted by the Engineer the load tests shall be completed before the remaining piles in the same structure are driven or cast.

(b) Load tests shall be performed on the day indicated by the Engineer. The Engineer may order load tests to be performed on piles other than

test piles and may also specify different increments of load, more frequent loadings of gauges and different period of loadings than specified herein or in Sub-clause 1614 (2). Such changes shall not continue any claim by the Contractor for any additional payment or compensation other payment for test pile and load test in accordance with the contract unit price quoted by the Contractor in the Bill of Quantities.

(c) Load tests shall be made by method approved by the Engineer. The Contractor shall submit to the Engineer detailed plans of loading system and apparatus he intends to use at least 3 weeks in advance. The apparatus shall be so constructed so as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. Tension anchor piles, if used, shall be of a design and driven to a depth satisfactory to the Engineer. Steel shells or piles whose walls are not of adequate strength to withstand the test loading when empty, shall have the required reinforcement and concrete placed before loading.

(d) The load test shall not be started until the concrete has attained a minimum compressive strength of 95% of specified strength. If the Contractor so selects, he may use high early strength cement (but not high alumina cement) in the concrete of the load test pile and the tension piles in order to decrease the time for load testing.

(e) Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of three times the design load for the pile being tested. Reference points for measuring pile settlement shall be sufficiently removed from the pile to preclude all possibility of disturbance.

(f) All pile load settlements shall be measured by adequate devices, such as gauges, and shall be checked by means of an Engineer's level. Increments of deflection shall be recorded just after application of each load increment and at 15 minutes intervals thereafter. The safe allowable load shall be considered as 50 percent of the load which, after 48 hours of continuous application, has caused not more than 6 mm of permanent settlement, measured at the top of this pile.

(g) The first load to be applied to the test pile shall be 50% of the pile design load and the first increment shall be up to the pile design load. The load on the pile shall be increased to twice the design load by applying additional loads in three equal increments. A minimum periods of 2 hours shall intervene the application of each increment. If there is a question as to whether the test pile shall support the test load, the load increments shall be reduced by 50 percent, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted.

(h) When directed by the Engineer load tests shall be continued beyond twice the design load in 10-ton increments to failure or to a maximum of 3 times the design load.

1615. FILLING EXISTING WATERCOURSES

The Contractor shall keep records as indicated below for the installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after the pile was installed. The signed records shall from a record of the work. The following data shall be recorded.

(a) Pile reference number.

(b) Pile location.

(c) Pile type.

(d) Nominal cross sectional dimensions or diameter.

(e) Date and time of boring.

(f) Date and time of concreting.

(g) River bed level at commencement of installation of pile.

(h) Working level.

(i) Pile toe level.

(j) River water levels.

(k) Pile head level.

(l) Length of temporary casing with top level.

(m) Length of permanent casing with top level.

(n) Soil samples taken and in situ tests carried out.

(o) Standing water level.

(p) Length and details of reinforcement.

(q) Concrete mix.

(r) Volume of concrete supplied to pile and corresponding levels of concrete and casings.

(s) All information regarding obstruction delays and other interruptions to the sequence of work.

(t) Sequence of driving/boring shown in plan of pile group.

(u) Final set of last ten blows.

(v) Type and weight of hammer.

(w) Type and condition of helmet and dolly.

(x) Details of any interruption in driving, boring and/or concreting.

(y) Other information as required by the Engineer.

Those information which are not applicable for the given type of pilling work may be omitted.

1616. MEASUREMETN

The piles shall be measured in line metres of pile as completed and accepted in the structure. Pay lengths of the accepted piles shall be measured from the butt of the shoe to the cut-off level of the pile shown on the Drawing or as instructed by the Engineer. No allowance shall be made for cut-offs or reinforcing steel projecting into the concrete structure as called for in the Drawing. Any additional pile lengths that may be necessary to suit the Contractor's method of operation or for any other reasons shall not be included in the measurements.

Test piles shall be measured per number of load test carried out including the complete installation of the pile. Piles driven by the Contractor for his own information or for calibrating diesel hammers shall not be measured as test piles.

1617. PAYMENT

The quantities of pilling left in place in the accepted structure, measured as provided above, shall be paid at the contract unit rate. The contract unit rate shall be the full and the final compensation to the Contractor for all expenditures incurred by the Contractor for incidentals and for doing all the works involved in driving, placing filling materials for cast-in-situ or driven piles, cutting off piles as specified in this specification in addition to those specified in Clause 112.

Pile shoes when called for on the Drawing or by the Engineer shall not be paid for separately, but full compensation for all the work involved in supplying and fitting pile shoes shall be considered as included in the unit rate for pre cast concrete piles and no additional compensation shall be allowed.

Splicing of piles, when allowed, shall not be paid for separately but full compensation for all the work involved shall be considered as included in the unit rate fro pre cast concrete piles.

Additional quantities of concrete, reinforcement and form work, caused by incorrect location of piles or additional piles necessary to replace defective piles shall be at the Contractor's expense.

Test piles shall be paid at contract unit rate which shall be full and final compensation for the cost of all operations and incidental costs associated with supply of piles in place and testing there of in addition to those specified in Clause 112.

SECTION 1700 – WELL FOUNDATION

SECTION 1700 – WELL FOUNDATION

1701. SCOPE

This work shall consist of construction of well, taking it down to the indicated levels, plugging the bottom and top including filling inside of the well in accordance with the details shown on the Drawing or as approved by the Engineer.

When the Drawing do not include details of the ground tests made on or near the centre line of wells the Contractor shall carry out at his own expense one bore/drill holes per well with penetration test (or similar approved tests). The depth to which the bore/drill holes tests are carried out shall be determined by the Engineer. A bore/drill hole log and a record of the tests and bagged or bottled samples of material shall be supplied to the Engineer for determining foundation depth of the wells.

1702. GENERAL

The well curb shall be of reinforced cement concrete. The well steining shall be of plain or reinforced cement concrete as indicated on the Drawing. The Specifications for plain and reinforced cement concrete, steel reinforcement and structural steel work and cutting edge shall be as given in the relevant sections of these Specification

1703. CUTTING EDGE AND CURB

The dimension and shape of the cutting edge and curb shall be strictly in conformity to Drawing or as directed by the Engineer. The well curb shall be placed truly in position and level. It may be precast or cast-in-situ, if it is cast in situ, all concreting in the well curb shall be done in one continuous operation. The well curb shall be allowed to set for at least 7 days before sinking is started.

When the curb is to be laid in dry beds, the site shall be excavated upto 300 mm above the sub-soil water level before the cutting edge is placed.

For well which are to be pitched in water, an earthen/sand island where possible, shall be constructed and curb shall be placed or cast on this island. In case of any deep or fast flowing water where an island may not be possible to construct the curb may be precast, floated and lowered in its final position with the help of necessary equipment.

For wells going through bouldery strata requiring use of explosives as an aid for well sinking, the entire inside surface of the well curb and steining upto a minimum height of 1 metre above the well curb, shall be protected by a 6 mm thick mild steel plate which shall be suitably stiffened.

The cutting edge shall be designed by the Contractor to the satisfaction of the Engineer, if otherwise not specified in the contract.

1704. STEINING

The dimensions and shape of the well steining shall strictly conform to those shown on the Drawing.

The steining of the well shall be built in one straight line form bottom to top, the worked being checked carefully with the aid of straight edges of lengths approved by the Engineer. Steining built in the first stage shall not be more than 2 metres and in subsequent stages it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at a time. As far as possible, the stages of work shall not be kept at the location of joints in the vertical steining bars.

The height of steining shall be calibrated by at least 4 gauges on the outer periphery and at centre lines of the well drawn at right angle to each other. The gauge shall be marked each in the form of a 100 mm wide strip painted on the well, with every 500 mm mark shown in black paint. The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be done carefully with a steel tape.

After sinking of a stage is complete all damaged portions of steining at top of the previous stage shall be properly repaired before constructing the next stage.

1705. SINKING

(1) General

The well shall be maintain in plumb and in the correct position during sinking and immediate steps shall be taken to remedy any deviations. The well shall be sunk by excavating material uniformly form inside the dredge hole. Sinking or loading of the well with kentledge shall be commenced only after the steining has been cured for at least 48 hours or as specified in the approved Drawing. The Contractor shall supply all grabs, water jetting equipment, pumps, diving gear and other equipment required for the sinking and founding of the wells and shall allow the Engineer and his nominees for the use of diving suit and apparatus for inspection purpose. Details of the equipment to be used in construction of the well shall be submitted to the Engineer for approval within 28 days of the award of the contract.

(2) Kentledge or Sinking Load

Kentledge shall be placed in an orderly and safe manner and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well.

(3) Dewatering of Well

Normally dewatering of well shall not be permitted as a means for sinking the well. It also shall never b e resorted to if there in any danger of sand-blowing under the well. If permitted, dewatering shall be carried out from points outside the well. Dewatering form within a well being excavated shall not be allowed other than in rock. Measures of controlling the effects of dewatering shall be adopted. When dewatering is permitted, adequate standby pumps shall be available at any time during well excavation in case of break down.

(4) Water Jetting

Water jetting may be employed for well sinking wherever necessary.

(5) Use of Explosives

Explosives shall not be generally used as an aid for well sinking. However, in case where explosives are to be used, they shall be of mild charges and prior approval of the Engineer shall be obtained. Blasting of any sort shall only be done in the presence of Engineer and not before the concrete/masonry in the steining has hardened sufficiently and is more than 7 days old.

If blasting has been used for setting the well after it has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid.

The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances on any damages to the curb or to the steining of the well.

All prevalent laws concerning handling, storing and using of explosives shall be strictly followed.

(6) Precautions during Sinking

The Contractor shall submit to the Engineer at least 28 days prior to the commencement of well sinking construction proposals to ensure safety of persons working on or liable to enter into the well excavation.

Notwithstanding guard rails and toe boards shall be provided around the top of well excavation at all times.

When the wells have to sunk close to each other and distance between them is not greater than the diameter of wells, sinking shall be taken up on all wells and they shall be sunk alternately so that sinking of all wells proceeds uniformly and together.

In sinking dump-bell or double-D shaped wells, the excavation in both the dredge holes should be carried out simultaneously and equally to facilitate even sinking.

All wells on which sinking is in progress shall be sunk to sufficient depth below the designed scour level before the start of seasonal floods. Further, they shall be temporarily filled and plugged before the onset on the floods so that they do not suffer any tilt or shift.

All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

The dredged material shall not be allowed to accumulate over the well. It shall be dumped, as far way from the well as possible, and then it shall be simultaneously removed to a safer place.

In case the river stream flows along one edge of the well being sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

Very deep sump shall not be below the well curb, as it entails risk of jumping (sudden sinking) of the well; normally the depth of sump shall not exceed 3.0 metres below the level of the cutting edge unless otherwise specifically permitted by the Engineer.

In case a well sinks suddenly and with a jerk, the steining of the well shall be examined to the satisfaction of the Engineer to see that no damage has occurred to it.

(7) Tilts and Shifts

Tilt and shift of each well shall be measured regularly during the entire sinking operation. Observations to this effect shall be taken at each stage of casting of the steining. Simultaneously as the sinking proceeds, necessary corrective measures be taken to contain the tilts and shifts within the permissible limits.

Unless otherwise specified the tilt of any well shall not exceed 1 in 80 and the shift shall not be more than 150 mm.

1706. BOTTOM PLUGGING

Before bottom plugging is resorted to, the Contractor shall take from the bottom of the excavation an undisturbed soil or sample (in the form of a core 3 m long and at least 70 mm diameter). In case the soil encountered is inferior to that adopted in design, the well shall be redesigned by the Engineer adopting the soil properties actually encountered and the founding level of the well duly revised.

Each well, after being sunk to its final position shall be insured that the whole steining has not developed cracks for its entire length. The sum shall be checked that it is uniform. If required, it shall be made uniform by resuming minor excavation in the dredge hole.

Before commencing bottom plugging, all the loose material from the bottom of the well shall be removed and the depth of the bulb so formed more than 1/6th diameter of the well shall be filled up with sand and then with concrete.

The concrete mix used in bottom plug shall have a minimum cement content of 330 kg/m^3 and a slump of about 150 mm to permit easy flow of concrete through tremie to fill up all cavities.

Concrete for the plug shall be laid by 'Tremie Pipe' method by skip boxes or any other method if stipulated in the contract. Concrete shall be laid evenly inside the well.

Least disturbance shall be caused to the water inside the well while laying concrete in the bottom plug where concreting is placed under the water this shall be carried out in accordance with Clause 2007.

Concreting shall be done in one continuous operation till dredge hole is filled upto the required height and thereafter sounding shall be taken or other approved method of measurement shall be applied to ensure that the concrete has been laid to the required height.

Concrete as laid shall not be disturbed in any way for at least 14 days.

In order to check any rise in the level of the bottom plug, sounding should be taken at the close of concreting and for 3 days thereafter once every day.

1707. SAND FILLING

When the bottom plugging is approved by the Engineer the well shall be filled with sand. A minimum of 3 days after the bottom plug has been laid shall elapse before the well is filled with sand.

Before filling with sand, the height of the bottom plug shall be verified.

Sand to be filled shall be clean and free from earth, clay clods, roots and boulders.

1708. TOP PLUG

After filling the sand upto the required height, top plug shall be laid over it. The thickness of this plug and the cement concrete mix to be used shall be as indicated on the Drawing.

1709. MEASUREMENT

Cutting edge shall be measured in tonnes inclusive of its connections. For computation of weight the specific gravity of steel shall be adopted 7.85 tonne per cubic metre.

Concrete for bottom plug shall be measured in cubic metre as per actual consumption of cement, sand and aggregate.

Concrete for curb, well steining and top plugging shall be measured in cubic metre as specified in Clause 2917.

Reinforcement used in the well shall be measured in tonne as specified in Clause 2017.

Formwork shall be measured in square metre inclusive of struts, sports, scaffolding etc. necessary as to complete the item as specified in Section 1800.

Sand filling shall be measured in cubic metre.

Boring/drilling shall be measured in running metres as specified in Section 3000.

Well sinking shall be measured in linear metres as described below.

From 0 m upto 3 m
From 3 m upto 6 m
From 6 m upto 9 m
From 9 m upto 12 m
From 12 m upto 15 m
From 15 m upto 18 m
Below 18 m at the rate of each metre.

The depth of measurement shall be started considering level of the bottom of cutting edge as zero.

1710. PAYMENT

Cutting edge, concrete for bottom plugging, various classes of concrete for curb, well steining and top plugging, reinforcement, sand filling, formwork and boring/drilling shall be paid at their respective contract unit rates.

The well sinking shall be paid as per contract unit rate for different depths.

The contract rate shall be the full and the final compensation to the Contractor as per Clause 112 and also include cost of formation of island, dewatering, excavation, bailing out materials, providing, placing and removal of kentledge and other operations including incidental costs necessary to complete the item as per this Specification.

SECTION 1800 – FLASEWORK, FORMWORK AND SURFACE FINISH FOR CONCRETE STRUCTURES

SECTION 1800 – FLASEWORK, FORMWORK AND SURFACE FINISH FOR CONCRETE STRUCTURES

1801. SCOPE AND DEFINITIONS

This section covers the preparation, construction and removal of falsework and formwork for concrete structures. It also covers the quality requirements for surface finish on formed and unformed surfaces.

Definitions used in this Clause and other relevant Clause of this Section and other relevant Sections of these Specifications are as follows:

- Formwork means the surface against which concrete is placed to form a face. All the immediate support necessary to retain the surface in position while concrete is placed, shall be treated an integral part of formwork.

- Falsework means the structural elements supporting both the formwork and the concrete until the concrete becomes self supporting.

- A formed face is one which has been cast against formwork.

- An unformed surface means an horizontal or nearly horizontal surface which is not cast against form work.

- An exposed face is one which will remain visible when construction has been completed.

1802. GENERAL

The Contractor shall be responsible for designing and construction falsework and formwork so that they will support the loads imposed on them by the fresh concrete together with additional stresses imposed by vibrating equipment and by construction traffic, and so that after the concrete has hardened the formed faces shall be in the positions shown on the Drawing within the tolerances set out in Clause 1805.

Before construction begins, the Contractor shall submit to the Engineer Drawing showing details of the proposed formwork and falsework in accordance with this Section and other relevant Section of these Specification.

1803. FALSEWORK

(1) Design and Drawing

The design of all falsework for structures with span lengths of 6 metres or more and the design of all falsework where traffic openings are specified shall conform to the requirements of this Clause.

Detailed working Drawing in triplicate and design calculations for falsework shall be furnished by the Contractor to the Engineer.

No falsework construction shall start until the Engineer has reviewed and approved the Drawing. The Contractor shall provide sufficient time for the Engineer to complete this review.

Such time shall be proportionate to the complexity of the falsework design and in no case shall be less than two weeks. The Contractor may revise the falsework Drawing at any time provided sufficient time is allowed for the Engineer's review and approval, before construction is started on the revised portion.

(a) Falsework Drawing

The falsework drawing shall include but not limited to the following:-

(i) The traffic openings.

(ii) A superstructure placing diagram, showing proposed concrete placing sequence and construction joints location.

(iii) Assumed values of soil bearing capacity for both wet and dry conditions, as determined by the Contractor.

(iv) Anticipated total settlements of falsework and forms.

(v) Details of drainage, if any.

(vi) Details of drainage protection (or scouring/undermining protection) of footing and/or foundations, including locations of existing utilities, excavations, recent fills if any.

(vii) Details of all elements required to insure the free movements of concrete due to shrinkage.

(viii) Proposed cambers to compensate deflections, and false adjustments according to the various stages of the construction and the concrete placing sequence.

(ix) Details of joints, bracing and major arrangements to insure vertical and horizontal stability in all direction and at all stages of operations.

(x) Manufacture's recommendations and/or other operating recommendations as required for the justifications for the design.

When a schedule for placing concrete is shown on the contract plans, no deviation shall be permitted there from unless approved in writing by the Engineer.

Anticipated total settlement shall not exceed 25 mm. This shall include falsework footing settlement and joints take-up. Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.

(b) Falsework Calculation

The calculations must show the stresses & deflections of all supporting members. The design of falsework shall be based upon the maximum loads, the maximum stresses and deflections and the conditions listed below. The stresses listed are based upon the use of undamaged high quality materials and such stresses shall be reduced by the Contractor if lesser quality materials are to be used. The Contractor shall be responsible for the proper evaluation of his falsework material and design of falsework to carry safely the actual loads imposed.

(i) The design loads for falsework shall consist of the sum of dead and live vertical loads and horizontal load.

(ii) The vertical design loads for the combined live and dead loads shall not be less than the actual required loads with due allowance for dynamic loads. However, it shall not be less than 0.5 t/m^2.

(iii) Dead load shall include the weight of concrete, reinforcing steel, forms and falsework.

(iv) Live load shall consist of the actual weight of the equipment to be supported by falsework, applied as concentrated loads, at the points of contact and a uniform of and less than 0.1 t/m^2 applied over the area supported, plus 0.11t/lm applied at the outside edges of deck overhangs.

(v) The horizontal loads to be resisted in any direction by diagonal bracing, ties or other means approved by the Engineer shall not be less than 2 percent of the total dead load.

(vi) Falsework footing shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing capacity and anticipated settlements.

(vii) If the concrete is to be prestressed, the falsework shall be designed to support increased or readjusted loads caused by the prestressing forces.

(viii) Joists supporting slabs and overhangs shall be considered as falsework and they shall be designed for the maximum loading and deflections loading and deflections permissible on jacks, brackets, columns joists and other manufactures devices shall not exceed the manufacturer's recommendations and in all cases their deflections shall be less than 1/270 of their clear span.

If requested by the Engineer, the Contractor shall furnish catalogue data listing the manufacturer's recommendations for manufactured devices and perform tests as necessary to demonstrate the adequacy of any such device proposed for use.

Falsework designed for prestressed concrete shall allow for the required free movements during prestressing operations.

When footing foundations are to be used, the bearing capacity of the soils shall be determined by the Contractor using the Plate Load Test method. The soil surface must be prepared adequately to allow for a relevant implementation of this test. Tests shall be carried out in both dry and wet conditions.

(c) Falsework over or Adjacent to Roadways

In addition to the minimum requirements specified above, falsework over or adjacent to roadways, where falsework opening are specified, shall be designed and constructed so that the falsework will be stable if subjected to impact by vehicles. The falsework design in such cases shall include, but not be limited to the following minimum provisions:

(i) The vertical design load of falsework bents, including footing and caps which support the portion of the falsework over openings shall be increased to not less than twice the design load calculated in accordance with Sub-clause 1803 (1) (b).

(ii) Each falsework post adjacent to openings shall be securely anchored to its withstand footing or otherwise laterally restrained at its base so as to withstand a 0.9t force applied at the base of the post in any direction except toward the road track.

(2) Construction

The falsework shall be constructed to substantially conform to the falsework Drawing.

The materials used in the falsework construction shall be of the quality necessary to sustain the stresses required by the falsework design.

The workmanship used in falsework construction shall be of such quality that the falsework will support the loads imposed on it without excessive settlement to take-up beyond that shown on the falsework Drawing. Falsework shall be founded on a solid footing safe against undermining protected under softening, and capable of supporting the loads imposed on it. When false work is supported on piles, the piles shall be driven to a bearing value determined in accordance with IS 2911.

When falsework is over or adjacent to roadways or waterways, all details of the falsework system which contribute to horizontal stability and resistance to impact shall be installed at the time each element of the falsework is erected and shall remain until the falsework is removed.

Suitable jacks or wedges shall be used in connection with falsework to set the forms at the required grade and to take up excessive settlement in the falsework either before or during the placing of concrete.

Comber strip shall be used as approved by the Engineer, to compensate the falsework deflection, vertical alignment and anticipated structure deflection. The Contractor shall provide tell-tales attached to the soffit and readable from the ground, in enough systematically placed locations to determine the total settlement of the entire portion the structure where the concrete is being placed.

Should unanticipated events occur, including settlements that deviate more than plus or minus 10 mm from those indicated on the falsework Drawing, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirements of this Specification, the placing of concrete shall be discontinued until corrective measures satisfactory to the Engineer are provide. In the event satisfactory measures are not provided prior to the initial set of the concrete in the affected area, the placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed.

The Contractor shall be responsible for the maintenance of falsework throughout the construction.

(3) Removal

Falsework shall not be released before the requirements of Sub-clause 1804 (3) are fulfilled.

Falsework for cast-in-situ prestressed concrete shall be released according to the prestressing sequences shown on the Drawing.

Falsework shall be removed uniformly and gradually to permit the structure to take its load slowly and evenly.

All falsework material shall be removed. Falsework pilling shall be removed upto at least 600 mm below the surface of the original ground or the bottom or side slope of excavated areas.

(4) Falsework for Steel Structures

Falsework for steel structures shall comply to the requirements of Sub-clause 1803 (1) to 1803 (4) in addition to the requirements of this Sub-clause.

Falsework and forms shall be constructed so that any loads applied to girder webs shall be applied within a distance to a flange or stiffener approved by the Engineer and shall be distributed in a manner that will not produce local distortion of the web.

Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and prevent appreciable relative vertical movement between the edge of deck forms and the adjacent steel girder.

1804. FORMWORK FOR CONCRETE

(1) Construction of Formwork

Joints in formwork for exposed faces shall, unless otherwise specified, be evenly spaced and horizontal or vertical and shall be continuous in a regular pattern.

All joints in formwork shall be water tight. Where reinforcement projects through formwork, the form shall fit closely round the bars.

Formwork shall be so designed that it may be easily removed from the work without damage to the faces of the concrete. It shall also incorporate provisions for making minor adjustments in position, if required, to ensure the correct location of concrete faces. Due allowance shall be made in the position of all formwork for movement and settlement under the weight of fresh concrete.

Surfaces at slopes less than 20^{o} may be formed by screeding. Surfaces at slopes between 20^{o} and 30^{o} shall generally be formed it the Contractor can demonstrate to the satisfaction of the Engineer that such slopes can be screeded with the use of special screed boards to hold the concrete in place during vibration.

Horizontal or inclined formwork to the upper surface of concrete shall be adequately secured against uplift due to the pressure of fresh concrete. Formwork shall also be tied down or otherwise secured against floating within the body of the concrete.

The internal and external angles on concrete surfaces shall be formed with fillets and chamfers of the sizes shown on the Drawing unless otherwise instructed by the Engineer.

Supports for formwork may be bolted to previous placed concrete provide the type of bolt used is acceptable to the Engineer. If metal ties through the concrete are used in conjunction with bolts, the metal left in shall not be close to the face of the concrete by less than 50 mm.

Formwork shall not be re-used after it has suffered damage which is sufficient to impair the finished surfaces of the concrete.

Where circumstances prevent easy access within the form, temporary openings shall be provided through the formwork for cleaning and inspection.

Shear keys of the size and shape as indicated on the Drawing shall be provided in all construction joints

Where precast concrete elements are specified for use as permanent formwork, or proposed by the Contractor and agreed by the Engineer, they shall comply with the requirements of formwork as specified in the Specification in respect of surface finish, strength and rigidity. Such elements shall be set true to line and level within the tolerances prescribed for the appropriate class of finish in clause 1806 and fixed so that they connot move when concrete is placed against them.

(2) Preparation of Formwork

Before any reinforcement is placed into position within formwork, the latter shall be thoroughly cleaned and then dressed with a release agent. The agent shall be either a suitable oil incorporating a wetting agent, an emulsion of water suspended in oil or a low viscosity oil containing chemical agents. The Contractor shall not use an emulsion of oil suspended in water nor any release agent which causes staining or discoloration of the concrete, air holes on the concrete surface, or retards the set of the concrete or affects the strength of concrete.

In order to avoid colour differences on adjacent concrete surfaces, only one type of release agent shall be used in any one section of the works.

In cases where it is necessary to fix reinforcement before placing formwork, all surface preparation of formwork shall be carried out before it is placed into position. The Contractor shall not allow reinforcement or prestressing tendons to be contaminated with formwork release agent.

Before placing concrete all dirt, construction debris and other foreign matter shall be removed completely from within the placing area.

Before concrete placing commences, all wedges and other adjusting devices shall be secured against movement during concrete placing and the Contractor shall maintain a watch on the formwork during placing to ensure that no movement occurs. If any movement noticed, the formwork shall be set right immediately.

(3) Removal of Formwork

Formwork shall be carefully removed without shock or disturbance to the concrete. No formwork shall be removed until the concrete has gained sufficient strength to withstand any stresses safely to which it may thereby be subjected.

The minimum periods which shall elapse between completion of placing concrete and removal of forms are given in Table 18-1 and apply to ambient temperatures higher than 10^{o} C. At lower temperatures or if cement other than ordinary Portland are involved, the Engineer may instruct longer periods.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 18.1, provided that the attained strength is determined by making test cubes and curing them under the same conditions as the concrete to which they refer.

Compliance with these requirements shall not relieve the Contractor of his obligation to delay removal of formwork until the removal can be completed without damage to the concrete.

If the Contractor wishes to strip formwork from the underside of arches, beams and slabs before the expiry of the period for supports set out above, it shall be designed so that it can be removed without disturbing the supports. The Contractor shall not remove supports temporarily for the purpose of stripping formwork and subsequently replace them.

As soon as the formwork has been removed, bolt holes in concrete faces other than construction joints which are not required for subsequent operations shall be completely filled with mortar sufficiently dry to prevent any slumping at the face. The mortar shall be mixed in the same proportions as the fine aggregate and cement in the surrounding concrete and with the same materials and shall be finished flush with the face of the concrete.

After of the formwork, the date of casting of concrete shall be marked on the surface of related concrete by water proof paint/marker for estimation of cuffing time.

Table 18.1: Minimum Periods for Formwork Removal

Position of Formwork	**Minimum period for temperatures over 10o C**	**Strength to be attained**
Vertical or near vertical faces of mass concrete	24 hours	0.2 f_{ck}
Vertical or near vertical faces of reinforced walls, beams colums	48 hours	0.3 f_{ck}

Underside of arches beams and slabs (formwork only)	4 days	0.5 f_{ck}
Supports to underside of arches, beams and slabs	14 days	f_{ck}
Arched linings in tunnels and underground works	24 hours	4 N/mm^2

***Note** : f_{ck} is the Characteristic Strength for the class of concrete used.*

1805. SURFACE FINISH ON FORMED SURFACES

Class of Finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawing and are defined hereunder:-

(1) Class F1 Finish

This finish is for surfaces against which backfill or further concrete will be placed. Formwork may be sawn boards, sheet metal or any other suitable material which will prevent the loss of laitance from the concrete being placed.

(2) Class F2 Finish

This finish is for surfaces which are permanently exposed to view but he highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thicknessed tongued and grooved boards with square edges arranged in uniform pattern and close jointed or with suitable sheet material. The thickness of boards or sheets shall be such that there shall be no visible deflection under the pressure exerted by the concrete placed against them.

Joints between boards or panels shall be horizontal and vertical unless otherwise directed. In this type of finish pitting, fins surface discoloration and other minor defects shall be remedied at the time and by methods agreed by the Engineer.

(3) Class F3 Finish

This is for surfaces which will be in contact with water flowing at high velocity, and for surfaces prominently exposed to view where good appearance is of special importance. To achieve this finish, which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved uniform pattern. Wherever possible, joints between sheets shall

be arranged to coincide with architectural features or changes in direction of the surfaces.

All joints between panels shall be vertical and horizontal unless otherwise directed. Suitable joints shall be provided between sheets to maintain accurate alignment in the plane of the sheets. Unfaced wrought boarding or standard steel panels will not be permitted for Class F3 finish. The Contractor shall ensure that the surface is protected from rust marks, spillages and stains of all kinds.

(4) Curved Surfaces

For curved surfaces where F2 or F3 finishes are called for, the formwork face shall be built up of splines cut to make a tight surface which shall then be dressed to produce the required finish.

Alternatively single curvature surfaces may be faced with plastic or plywood linings attached to the backing with adhesive or with escutcheon pins driven flush. Linings shall not bulge, wrinkle or otherwise deform when subjected to temperature and moisture changes.

(5) Tolerances

All parts of formed concrete surfaces shall be in the positions shown on the Drawing within the tolerances set out in Table 18.2

In cases where the Drawing call for tolerances other than those given in Table 18.2 the Drawing shall rule.

Where precast units have been set to a specified tolerance, further adjustments shall be made as necessary to produce a satisfactory straight or curved line. When the Engineer has approved the alignment, the Contractor shall fix the units so that there in no possibility of further movement.

Table 18.2: Tolerances

Class of finish	Tolerances in mm (See Note)		
	A	**B**	**C**
F1	10	10	+25 to – 10
F2	5	10	±15
F3	2	5	±10

***Note**: The tolerances A, B and C given in the table are defined as follows:*

A is an abrupt irregularity in the surface due to misaligned formwork or defects in the face of the formwork.

B is gradual deviation from a plane surface as indicated by a straight edge 3 m long. In the case of curved surfaces the straight edge shall be replaced by a correctly shaped template.

C is the amount by which the whole or part of a concrete face is displaced form the correct positions shown on the Drawing.

1806. FINISHES ON UNFORMED SURFACES

Horizontal or nearly horizontal surfaces which are not cast against formwork shall be finished to the class shown on the Drawing and defined hereunder.

(1) UF 1 Finish

All surfaces on which no higher class of finish called for on the Drawing or instructed by the Engineer shall be given a UF 1 finish.

The concrete shall be leveled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction.

(2) UF 2 Finish

This is a floated finish for roof or floor slabs and other surfaces where a hard trawled surface is not required.

The surface shall first be treated as a class UF 1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficient only to produce a uniform surface free from screed marks.

(3) UF 3 Finish

This is a hard trowel led surface for use where weather resistance or appearance is important, or which is subject to high velocity water flow.

The surface shall be floated as for a UF 2 finish but to the tolerance stated below in Sub-clause 1806 (5). When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowel led under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

(4) Finishing of Bridge Decks

A smooth riding surface of uniform texture true to the required grade and cross section, shall be obtained in all bridge roadway decks.

The placing the concrete in bridge roadway decks shall not be permitted until the Engineer is satisfied that appropriate methods, equipment such as

concrete finishers and experienced operator, are employed to finish the deck, and all necessary finishing tools and equipment are available on site and in satisfactory conditions for use.

Bridge deck surfaces shall be within the tolerances state below in Sub-clause 1806 (5) for UF3 finish and comply with the following additional requirements:-

The finished surface of the concrete shall be tested by means of a straightedge 3 m long and when the surface is not covered by bituminous surfacing or other cover, the surface of the concrete shall not vary by more than 3 mm measured from the lower edge of the straightedge.

(5) Tolerances

All parts of unformed concrete surfaces shall be in the positions shown on the Drawing within the tolerances set out in Table 18.3.

In case where the Drawing call for tolerances other then those given in Table 18.3 the Drawing shall rule.

Table 18.3: Tolerances

Class of finish	Tolerances in mm (See Note)		
	A	**B**	**C**
UF1	Not applicable	10	+20 to – 10
UF2	Nil	10	+20 or – 10
UF3	Nil	5	+12.5 or – 7.5

***Note**: The tolerances A, B and C given in the table are defined as follows:*

A is the maximum allowable value of any sudden change of level in the surface.

B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three metre long straight edge or correctly shaped template place on the surface.

C is the maximum allowable value of the in level or position between a three meter long straightedge or correctly shaped template placed on the surface and the specified level or position of that surface.

1807. REMEDIAL WORK TO DEFECTIVE SURFACES

If no removal of any formwork the concrete surface is found to be defective in any way, the Contractor shall make no attempt to remedy such defects prior to the

Engineer's inspection and the receipt of any instructions which the Engineer may give

Defective surfaces shall not be made good by plastering.

Areas of honey combing which the Engineer agrees, shall be repaired after cutting back to sound concrete when the concrete is no more than 3 day old. Care shall be taken that reinforcement and sheathing ducts are not damaged. The cavity shall have sides at right angles to the face of the concrete. After cleaning out with water and compressed air, compressed air, a thin layer of cement grout shall be brushed on to the concrete surfaces in the cavity. It shall then be filled immediately with the concrete of the same class as the main body. The concrete shall be prepared from the aggregate of maximum size 0.5 times the depth of the cavity or 20 mm whichever is the smaller. A form provided with a lip to enable concrete to be placed shall be used against the cavity. The form shall be filled above the top edge of the cavity.

After seven days the lip of concrete shall be broken off and the surface shall be ground smooth.

When the concrete is more than three day old, areas of honey combing shall be repaired using an epoxy bonding agent with a method approved by the Engineer.

Surface irregularities which are outside the limits of tolerance set out in Clause 1806 shall be ground down in the manner and to the extent instructed by the Engineer.

Blowholes in vertical surfaces shall be filled with laitance, or mortar using fine aggregate not larger than 0.3 mm, rubbed over the affected area with a rubber face float and finished with polythene.

Defects other than those mentioned above shall be dealt with as instructed by the Engineer.

1808. MEASUREMENT

Except as stated below, formwork shall be measured in square metre of formwork actually in contact with the finished face of he concrete. No deduction shall be made in the measurement for openings pipes, ducts and the like, provided that the area of each is less than 0.50 square metres. Unless otherwise stated, if the volume or area of concrete has not been deducted when measuring the concrete, formwork to form box or the void shall not be measured.

Formwork less than 300 mm high to edges of slabs shall be measured in linear metre.

Inclined formwork shall be measured in accordance with the following classification:

(i) Horizontal; 85 to 90^{o} inclination from vertical
(ii) Sloping; 10 to 85^{o} inclination from vertical
(iii) Battered; 0 to10^{o} inclination form vertical
(iv) Vertical; 0^{o}
(v) Slopping upper surfaces inclined at more than 15^{o} from the horizontal.

Formwork required for lean concrete, to form construction joints and shear keys for future concrete and other construction surfaces shall not be measured and the costs shall be included in the rates for other work.

Form work to contraction and expansion joints shall be measured in square metre on one face only. The rates shall include for the costs stated below and for forming recesses for sealant and channels for grout.

The measurement of formwork is inclusive of the measurement for formwork finished surface, shoring staging, scaffolding and other accessories required for erection and removal of the formwork.

Formwork less than 300 mm high to edges of slab shall be measured in the linear metre.

1809. PAYMENT

The formwork shall be paid as per the contract unit rate. In addition to those specified in Clause 112 the rates for formwork shall include the cost of submission of details, transportation and use of all materials for formwork and falsework, erection including provision of supports, fillets and chamfers 75 mm and less in width, bolts, ties, fixing, cutting to waste, drilling or notching the formwork for reinforcement where required, working around pipes, ducts, conduits and waterstops, temporary opinings, cleaning, dressing, removal of formwork and falsework, filling bolt holes and any remedial work and for complying with Clause 2007, 2009, 2012 and Section 1800 including all incidental works required to complete the work as per Specification.

The payment for unformed surfaces of concrete shall be deemed included in the contract unit rate of the relevant concrete.

SECTION 1900 – BEARINGS AND EXPANSION JOINTS

SECTION 1900 – BEARINGS AND EXPANSION JOINTS

1901. EXPANSION JOINTS

(1) Scope

This Clause covers the works in connection with the fabrication and placing of expansion joints as shown on the Drawing to this Specification or as directed by the Engineer.

Expansion joints are defined as joints placed in gaps between the deck ends or the deck and the back wall. The purpose of the expansion joint is to permit free movement of the bridge deck due to thermal effect and rotational articulation, to prevent cracking in the surface layer by effectively supporting the surfacing and to prevent water and water-borne contaminants from invading the bearing area and substructure.

(2) General Requirement

(a) The expansion joints shall be robust, durable, watertight and replaceable. It shall be provided over the full width of the deck and follow the profile including kerb, footpath and facia. Expansion joints shall be obtained only from the approved manufacturers and be of proven type. Site fabricated expansion joints shall be prohibited.

(b) The expansion joints shall be strong enough to withstand the movements, displacements and rotations specified on the Drawing in conjunction with the loads prescribed in the Code of Practice adopted for the design of the structure without over stressing any part in terms of "working load" requirements or exceeding the requirement of serviceability for limit state design. Any strengthening of the supporting members required to resist forces imparted by the joint to the structures shall be at the Contractor's own expenses.

(c) The expansion joints shall be vibration free, resistant to mechanical wear and other forms of abrasion and shall resist corrosion. It shall have good riding characteristics, be skid resistant and silent. It shall have provision of the disposal of water or grit collecting in the joint and be of such construction so as to facilitate easy inspection, maintenance and repair.

(d) Prior to manufacture of the joints, the Contractor shall submit detail Drawing showing exact positions of all elements. Only after the approval of the Drawing by the Engineer, the Contractor shall start fabricating those parts.

(e) The Contractor may offer proprietary expansion joints already tested elsewhere in lieu of the type specified in the contract. The proprietary joints offered by the Contractor shall comply in all respects with the

manufacturer's specifications and meet the required range of movements and rotations and be and be fit purpose of ensuring satisfactory long term performance in the bridge.

(f) The compressing seal (for slab seal expansion joint) and strip seal (for seal expansion joint shall only be obtained from the reputed manufactures.

Following type of Expansion Joints are covered by this Specification:

- Steel Plate Sliding Expansion Joints
- Buried Joints
- Elastomeric Slab Seal Joint
- Strip Seal Joint

(3) Steel Plate Sliding Expansion Joints

(a) In this type of joint, the wearing coat shall be made continuous over the joint. The other alternative shall be to keep a gap in the wearing coat, which is filled up with a seal, and filler, to be provided in extremely hot areas.

(b) Material of steel plate shall conform to IS: 2062. The exposed metallic components shall be galvanized or coated with approved anti-corrosive paint. The thickness shall be 20 mm or so for obtaining satisfactory performance.

(c) Plates shall be placed to the line, grade and expansion gap shown on the Drawing with any adjustment required for temperature, care being taken with the top of the plates.

(d) Plates shall be firmly held in place during concreting by methods approved by the Engineer.

(e) Any temporary bolts or other fixing to hold the expansion plates in their correct positions which prevent relative movement of the adjacent parts of the joints shall be removed as soon as the concrete has sufficiently. In any case, temporary bolts or other fitting shall be removed within 6 hours of placing concrete unless otherwise directed by the Engineer.

(f) Care shall be taken to prevent damage to expansion joint plates or its coating.

(g) If any damage occur to the plates and coating, shall be restored by the Contractor to the satisfaction of the Engineer.

(4) Buried Joints

(a) The components of this type of joint shall be at least 2 mm thick corrugated copper plate placed slightly below the wearing coat, 20 mm thick compressible fibre board to protect the edges, 20 mm thick pre-moulded joint filler filling the gap upto the top level of the wearing coat, sealed with a joint sealing compound.

(b) 8 mm dia, 100 mm long nail spaced at 300 mm c/c along the centerline of the plate shall be welded to the bottom surface of the copper plate to protrude vertically into the joint gap in order to prevent dislodging of the plate.

(c) The plate and the nails shall be protected against corrosion by galvanizing or any approved anti-corrosive coating with a minimum thickness of 100 micron. These shall be completely free of oil, rust, loose paint or other similar material before applicable of anti-corrosive coating.

(d) The material used for filling expansion joint shall be bitumen impregnated felt elastomer or any other suitable material, as specified on the Drawing. Impregnated felt shall conform to the requirements of IS: 1838, and shall be got approved from the Engineer. The joint filler shall consist of large pieces. Assembly of small pieces to make up the required size shall be avoided.

(e) Expansion joint materials shall be handled with care and stored under cover by the Contractor to prevent damage.

(f) Any damage occurring after delivery shall be made good to the satisfaction of the Engineer at the expense of the Contractor.

(g) Joint gaps shall be constructed as shown on the Drawing. Surfaces of joint grooves shall be thoroughly cleaned with a wire brush to remove all loose material, dirt and debris, and then washed or jetted out.

(h) Pre-moulded expansion joint filler shall not be placed in position prior to the placing of the abutting material. If the two adjacent surfaces of the joint are to be placed at different times, this type of joint filler shall not be placed until the second face is about to be placed.

(i) Sealant shall be installed in accordance with the manufacturer's recommendations and all appropriate requirements for joint face priming.

(j) Sealant split or splashed onto finished surfaces of the bridge during joint filling operations shall be removed and the surface made good to the Engineer's approval.

(k) No joint shall be sealed until inspected by the Engineer and approval is given to proceed with the work.

(5) Elastometric Slab Seal Expansion Joint

(a) Material

(i) Steel inserts shall conform to IS: 2062. Use of any other materials like fiberglass or similar material shall not be permitted.

(ii) Elastomer for elastomeric slab unit (ESU) shall conform to clause 915.1 of IRC:83 (Part 2), compounded to give hardness IRHD 60±5, Subject to the following additional stipulations:

- Chloroprene (CR) only shall be used in the manufacture of elastomeric expansion joints. No reclaimed/natural rubber or vulcanized wastes shall be used.
- The chloroprene material used in the manufacture of elastomeric (expansion joint) shall be Neoprene WRT, Bayprene 110, Skyprene BS or Denka S-40V.
- The chloroprene content of the compound shall not be lower than 60 percent by weight. The ash content shall not exceed 5 percent (as test conducted in accordance with ASTM D-297).
- EPDM and other similar candidate elastomers for expansion joints shall not be permitted.

(iii) Elastomeric plugs

(iv) Spacer bars, marked with center to center distance of fixing holes.

(v) Fixing bolts and nuts made of stainless steel.

(vi) Anchor bars comprising hooked anchor stiffeners welded with lower steel inserts and sinusoidal anchor bars welded with horizontal leg of the edge steel inserts. The elaborate anchoring arrangements of steel inserts shall be permanently welded/tied with the steel reinforcement.

(b) Fabrication

(i) Steel inserts shall be grit blasted and provided with epoxy paint.

(ii) Edges of reinforcing steel sections shall be rounded.

(iii) Expansion joints shall be fully moulded to the required size in one single vulcanizing operation including the encasing layers as integral and homogeneous part.

(iv) Tolerances of fabrication shall be as folloes:

- Plan dimension ± 5 mm
- Total height ± 3 mm

(c) Supply and Handling

(i) The Contractor shall supply all steel-reinforced elastomeric expansion joints including bolts, nuts, sealant, plates and all other accessories for the effective installation of the joints including angled jointing sections for kerbs.

(ii) Expansion joint material shall be handled with care and stored under cover to prevent damage. Any damage occurring after delivery shall be made good at the expense of the Contractor to the satisfaction of the Engineer.

(d) Installation

Expansion joints shall be installed as per Drawing. Steel inserts, spacer bars, concreting of pockets, fixing of elastomer slab unit and presetting, etc., shall be done as per the followings:

Steel Inserts

(i) Deck casting shall be done leaving pockets or recess for steel inserts and anchors of the expansion joint as per the Drawing.

(ii) Steel inserts shall be lowered at the appropriate location the pocket.

(iii) The top of the insert shall be flush with the finished level of wearing course maintaining the camber.

(iv) Spacer bars shall be fitted under proper supervision.

(v) Anchor rods shall be tied/welded with the existing deck main reinforcement maintaining level and alignment.

(vi) Welding between anchor rods and deck reinforcement is preferable. If welding is not possible, strong steel tie wires shall be used for fastening, under proper supervision.

Space Bar

(i) Spacer bars shall be used to ensure proper positioning of bolts and also leveling of the steel inserts during fixing of the same with the deck reinforcement and casting second stage concreting in the pocket thereafter.

(ii) The second stage concreting operation shall be started within 24 hours of fixing the steel inserts. Spacer bars shall be removed just after concreting is finished. If there is a substantial time lag between fixing of inserts and concreting, then any one of the following methods shall be adopted, depending of the support condition:

- For simply supported bridge resting on simple elastomeric bearing, (with no dowel pins), insert shall be placed in position with spacer bars at every alternative joints. Such joints shall be called restrained joints hereafter. In other words, inserts shall not be fixed simultaneously at two ends of one span. If the above condition is satisfied, inserts with spacer bars shall be kept in position for a substantially longer period at such restrained joints. Space bars shall be removed after concreting of such restrained joints and inserts placed in position with spacer bars at the other unrestrained joints thereafter.

- For bridges resting on other than elastomeric bearings (including bearings with dowel pins at one end), after placing and aligning the inserts and securing the same, the spacer bars shall be removed. Concreting shall be done with great care so that insert are not dislocated or distorted.

(iii) While removing the spacer bar after concreting, care shall be taken to see that the concrete is not damaged during withdrawal of space bar. If the spacer bar happens to be snugly fitted, it shall not be pulled by any means: it shall be gas cut in two pieces and then removed.

Concreting of Pocket

(i) Concreting of pocket shall be done with great care using proper mix conforming to grade similar to that deck casting besides ensuring efficient bonding between deck and steel insert. Care shall be given for ensuring efficient bonding with the already cast concrete.

(ii) Needle vibrations shall be used. Care shall be taken so that the position of steel inserts is not disturbed during vibration.

(iii) Spacer bar shall be removed within an appropriate time before the joint is required to permit movement.

Fixing of Elastomeric Slab Unit (ESU)

(i) Special jig shall be used to pre-set the ESU during installation.

(ii) ESU (mounted on the jig) shall be lowered to position.

(iii) The line and level on the ESU shall be adjusted.

(iv) ESU shall be removed and coated and with special adhesive.

(v) ESU shall be placed in position again, ensuring waterproof joining at required faces.

(vi) ESU shall be tightened with stainless steel nuts and lock washers in position. Tightened nuts shall be locked with lock washers.

(vii) Special sealant shall be poured inside the plugholes.

(viii) The elastomeric plugs shall be pressed position after applying adhesive on the appropriate surface.

(ix) ESU shall be fitted in position after completion of wearing course. While completing this part of the wearing course, adequate care shall be taken to ensure a waterproof joining with the already existing wearing course.

Pre-Setting

The steel insert unit of expansion joint can be fixed in any month of the year. The expansion gap between bridge superstructure may vary from time to time; hence initial fixing distance between fixing points shall depend on the month of installation of steel insert. The c/c distance between stainless steel fixing of bolts as indicated on the Drawing shall be taken as only nominal. The same shall be modified by pre-setting depending on:

(i) The difference between the mean temperature of the month of fixing of steel insert and the annual average temperature.

(ii) The elapsed period between the casting and/or pre-stressing and fixing of steel inserts for calculating the remnant creep and shrinkage.

Special requirements for Installation

(i) Prior to construction of bridge deck area adjacent to the joint, the Contractor shall provide detailed working Drawing showing the location of all bolts, recesses and holes necessary for the installation of the joint. Reinforcing bars in superstructure shall be amended as required to ensure that there will be no interference in the installation of the joint.

(ii) All bearing surfaces and recesses, which are in contact with the joint assembly, shall be checked with a straight edge to ensure flatness of profile.

(iii) No holes shall be drilling for fixing bolts within 7 days of concreting. Holes for the bolts shall be drilled to the size and depth shown on the Drawings.

(iv) Sections of the jointing making the completed joint shall follow a straight line.

(v) The fixing bolts shall not be placed in a position until at least 28 days after stressing is completed in post-tensioned box or beam and slab structures. Prior to placing sections of jointing, contract surfaces shall be cleaned to remove all grease, tar, paint, oil, mud or any other foreign material that may affect adhesion of the sealant.

(vi) Sealant shall only be applied be to dry contact surfaces. Sufficient sealant shall be applied to the contact surfaces to cause extension of sealant when the jointing is fixed in position.

(vii) Final sealing of the finished expansion joint shall be completed immediately after completion of installation. All exposed ends, joints between units and other areas of possible leakage shall be filled with sealant. All voids between the sides of the jointing and concrete or plates shall be filled with sealant.

(viii) Bolt cavities shall be cleaned and plugged with neoprene cavity plugs. Prior to placing the plugs sufficient sealant shall be placed in the cavities to cause extrusion of the sealant be the plugs.

(ix) All excess sealant shall be removed from the jointing and adjacent areas.

(e) Acceptance Test

As per Clause 918.7 of IRC (Part 3), necessary quality control certification by manufacturer in regard to properties of Elastomer and steel shall be furnished by the Contractor.

For severe environment, ozone resistance test as per Clause 915.2.3 of IRC: 83 (Part 2), shall be carried out for elastomer.

The properties of the elastomer shall conform to Table 1 of Clause 915.2 of IRC: 83 (Part 2). The acceptance testing for elastomer material shall conform to Clause 918.4.1.2 of IRC: 83 (Part 2) with additional criteria as stated in Sub-clause 1902 (5).

The fabricated expansion joint shall be subjected to the following acceptance tests:

(i) Routine test: Each expansion joint shall be tested for a least 100 cycles for a test movement, which shall be 10 per cent more than the design expansion contraction movement.

(ii) In addition to routine test, one out of every 20 –expansion joint shall be subjected to the test movement for 4000 cycles.

(iii) The type test for abrasion resistance shall be carried out to for one joint out of every 20 nos. as per IS: 3400 (3) and the standard deviation shall be within ± 20 per cent.

N.B.: The Contractor's manufacturer shall have in-house testing facility. Alternatively, the testing shall be got done by him at his expense at any testing establishment selected by the Engineer. A manufacturer who cannot carry out the acceptance test shall not be entitled to supply elastomeric slab seal joint.

(6) Strip Seal Joint

(a) Components

Strip seal expansion joint shall comprise the following items:

(i) Edge Beams: This special claw leg profiled member shall be extruded rolled steel section combing good weld ability with notch toughness.

(ii) Strip seal: This shall be of chloroprene with high tear strength, insensitive to oil, gasoline, and ozone. It shall have high resistance to aging. This component, provide to ensure water tightness, shall have bulbous shape of the part of the seal, which is inserted into the groove, provided in the edge beam. The seal

should be vulcanized in single operation for minimum full length of joint.

(iii) Rigid Anchorage: This shall be made of weld able steel connecting the rigid anchorage with deck reinforcement.

(b) Material

(i) The steel shall conform to steel grade Rst 37-2 of German Standard or equivalent.

(ii) Chloroprene of strip seal shall conform to Clause 915.1 of IRC: 83 (Part 2). The properties of chloroprene shall conform to Table 19.1.

(iii) Anchorage steel shall conform to IS: 2062.

(iv) Anchor loop shall conform to IS: 2062.

Sealing element shall be made of chloroprene and shall be a extended section. The working movement range of the sealing element shall be at least 80 mm with a maximum of 100 mm at right angles to the joint and ± 40 mm parallel to the joint. The properties of strip seal element shall be as given in the Table 19.1.

Table 19.1: Specification for Strip Seal Element (Chloroprene)

Property	**Specified Value**
Hardness	63 ± 5 Shore A
Tensile Strength	Min. 11 N/sq.mm
Elongation at fracture	Min 350 per cent
Tear Propagation Strength	
Longitudinal	Min 10 N/mm
Transverse	Min 10 N/mm
Shock Elasticity	Min 25 per cent
Abrasion	Min 220 mm^3
Residual Compressive Strain (22 h/70^o C / 30 per cent strain)	Max 28 per cent
Ageing in hot air (14 days/10^o C)	
Change in hardness	Max + 5 Shore A
Change in tensile strength	Max – 20 per cent
Change in elongation at fracture	Max – 20 per cent
Ageing in ozone (24 h/50 pphm/25^o C / 20 per cent strain)	No cracks

Swelling behavior in Oil (116 h/25 per cent C) ASTM Oil No.	
Volume Change	Max 5 per cent
Change in hardness (ASTM Oil No. 3)	Max 10 Shore A
Volume Change	Max 25 per cent
Change in hardness	Max 20 Shore A
Cold Hardening Point	Min – 35^{o} C

(c) Fabrication (Pre-installation)

(i) Rolled steel profiles for edge beams shall be long enough to cater for a 2-lane carriageway. These shall be cut to size of actual requirements by means of a mitre box saw. Alignment of the cut-to-size steel profiles shall then be made in accordance with the actual bridge cross-section on worktables. For this purpose, the contour of bridge cross-section shall be sketched onto these tables. After the steel profiles are aligned, they shall be chucked to the tables by means of screw clamps and tacked by arc welding.

(ii) Anchor plates shall be cut to the required size by gas cutting. These shall be welded to the edge beams.]

(iii) Anchor loops shall be bent to the required shape and welded to anchor plates.

(iv) The finally assembled joints shall be clamped and transported to the work site.

(d) Handling and Storage

(i) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.

(ii) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding to prevent damage. Any damage occurring after delivery shall be made good by the Contractor at his expense to the satisfaction of the Engineer.

(e) Installation

(i) The width of the gap to cater for movement due to thermal effect, pre-stress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is likely to be installed, the gap dimension shall be pre-set.

(ii) Taking the width of gap for movement of the joint into account, the dimensions of the recess in the decking shall be established in accordance with the Drawing or design data of the manufacturer. The surfaces of the recess shall be thoroughly cleaned and all dirt and debris removed. The exposed reinforcement shall be suitably adjusted to permit unobstructed lowering of the joint into the recess.

(iii) The recess shall be shuttered in such a way that dimensions in the joint is maintained. The formwork shall be tight.

(iv) Immediately prior to placing the joint, the pre-setting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for pre-setting, correction of the pre-setting shall be done. After adjustment, the brackets shall be tightened again.

(v) The joint shall be lowered to the pre-determined position. Following placement of the joint in the prepared recess, the joint shall be leveled and finally aligned and the anchor loops on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side of the joint. With the expansion joint finally held at both sides, the auxiliary brackets should be released, allowing the joints to take up the movement of the structure.

(vi) Concrete shall then be filled into the recess. The packing concrete shall feature low shrinkage and have the same strength as that of the superstructure, but in any case not less than M 35/10 grade. After the concrete has cured, the movable installation brackets still in place shall be removed.

(vii) Rolled up neoprene strip seal shall be cut in to the required length and inserted between the edge beams by using a crow bar pushing the bulb of the seal into the steel grooves of the edge beams. A landing to a bead shall be formed in the thickened end of the edges of the seal, which would force the thickened end against the steel beams due to wedge effect when the strip seal is buttoned in place.

(viii) As soon as the concrete in the recess has become initially set, a study ramp shall be placed over the joint to protect the exposed steel beams and neoprene seals from traffic. Expansion joint shall not be exposed to traffic loading before the carriageway surfacing is placed.

(ix) The carriageway surfacing shall be finished flush with the top of the steel sections. The actual junction of the surfacing/wearing

coat with the steel edge section shall be formed by a wedge shaped joint with a sealing compound. The horizontal leg of the edge beam shall be cleaned beforehand. It shall be ensured that thorough compaction of the surfacing in is made in order to prevent any premature depression forming in it.

(f) Acceptance Test

(i) All steel elements shall be finished with corrosion protection system.

(ii) For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table 19.1. It shall also be stretch tested. The Contractor shall produce test certificates conducted in a recognized and approved laboratory.

(iii) Investigation of fatigue strength of the section with anchorage to withstand 2 x 106 load change cycles without showing signs of damage shall be required. The Contractor shall produce a test certificate in this regard, conducted in a recognized and approved laboratory.

(iv) The Contractor shall produce test certificates indicating that anchorage system had been tested in a recognized and approved laboratory to determine optimum configuration of anchorage assembly under dynamic loading.

(v) The Contractor shall satisfy the Engineer that water tightness test for the type of joint has been carried out in an approved laboratory to check the water tightness under a water pressure of 4 bars.

(vi) The Contractor shall produce evidence of satisfactory performance of this type of joint.

(7) Measurement

Expansion joint shall be measured in linear meter inclusive of all axillary and incidental works. Measurement shall be made along the joint between the outside faces of the deck.

(8) Payment

Expansion joint measured as provided above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 and for all incidental costs necessary to complete the works as per these Specifications.

1902. BEARINGS

(1) Scope

The Clause covers the work in connection with the furnishing and fixing bearings in position in accordance with the details shown on the Drawing to the requirements of these Specifications or as directed by the Engineer.

(2) General

(a) Bearing plates, bars, rockets, assemblies and other expansion or fixed devices shall be constructed in accordance with the details shown on the Drawing.

(b) All bearing shall be capable of being replaced during the lifetime of the structure and shall be robust, durable and proven type obtained from the approved manufacturers, who can provide complete facilities for raw materials and finished products.

(c) The Contractor shall exercise care in setting and fixing all bearing in their correct positions and ensuring that uniformity is obtained on all bearing surfaces.

(d) Bearings shall be handled with care and stored under cover.

(e) When bearing assemblies or plates are shown in the Drawing to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade (not exceeding 12 mm) and shall be finished by grinding.

(f) It shall be ensured that the bearings are set truly level and in exact positions as indicated on the Drawing so as to have full and even bearing on the seats. Thin mortar pads (not exceeding 12 mm) may even be made to meet with this requirement. The finished level plane shall not vary more than 4 mm from the level shown on the Drawing.

(g) It shall be ensured that the bottoms of girders to be received on the bearing are plane at the locations of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

(h) The anchor bolts, if shown on the Drawing, shall be installed to permit true positioning of the bearing assemblies. The drilled holes for fixing the bolts shall be completely filled with mortar consisting of 1 part of cement: 2 part of sand.

(3) Metallic (Steel) Bearings

(a) Materials

Materials for Steel Bearing shall comply to Section 2200 of these Specifications.

Some additional requirements for materials for steel bearing are indicated below.

(i) Railway axles (R 19) are also acceptable as forged steel for rollers.

(ii) For purpose of checking the soundness of cast steel components, castings shall be ultrasonically examined following procedure as per IS: 7666 with acceptance standard as per IS: 9565. The casting may also be checked by any other adopted method of non-destructive testing as specified in IS: 1030. Quality level of casting shall be level 3 as per IS: 9565.

(iii) The Contractor shall submit manufacturer's certificate regarding composition of raw material. Confirmatory tests regarding composition may be required by the Engineer. In such cases, the Contractor shall arrange the facilities for such tests at his own expense.

(iv) Machining: appropriate machining technique like tuning, shaping, planning, drilling, milling, grinding etc shall be adopted depending upon the required tolerance, surface finish and the size of the item.

(v) Coating

- Mating surface shall be covered with fallow which shall be removed after installation and grease shall be applied.
- Non mating surfaces shall be painted with red lead or epoxy based painting.
- If Specified, corrosion resistant coating like galvanizing, spray coating with aluminium or zinc shall be applied

(b) Construction Operations

(i) All work shall conform strictly to the Drawing. Care shall be taken to ensure that all parts of an assembly fit accurately together.

(ii) Knuckle pins, rolling surface of the rollers and bearing surface of the bearing plates shall be machined and all bolt holes shall be drilled. The whole bearing shall be fitted and finished as required for good quality machined work to the satisfaction of the Engineer. However, in case of bearings which are to be grouted or bedded on a suitable yielding material on any surface which is to be in permanent contact with the grout or the yielding material may be left unmahcined.

(iii) In pre-stressed concrete construction where launching of girders is employed, adequate measures shall be taken to ensure that the roller assembly is not disturbed in order to avoid slipping or jumping of rollers due to vibration or jolts.

(iv) During concreting of girders, the bearings shall be held in position securely by providing temporary connection between the top and bottom plates in case of fixed bearings and between top plate, base plate and saddle plate in case of roller cum rocker bearing or by any other suitable arrangement which prevents the relative displacement of the components.

(v) In pre-stressed pre-cast girders, where recesses are left on the underside of girders to receive the anchor bolts, grout holes extending to the beam sides or to the deck level shall be provided. The cement san grout shall have a mix of 1:1 ratio.

(c) Workmanship

(i) Fabrication shall be carried out by approved experienced and qualified manufacturer to undertake precision engineering of this type.

(ii) Workmanship shall be of good quality, neatly finished and of good appearance.

(iii) Casting shall be true to the forms and dimension shown on the Drawing and shall be free from pouring faults, sponginess, cracks, blowholes and other defects on position affecting their appearance or strength. Warped or distorted casting shall not be accepted. Exposed surfaces shall be smooth and dense.

(iv) All casting shall be cleaned by sand or shot blasting to remove sand or scale and to present a clean uniform surface.

(v) All irregularities, fins or risers shall be ground off flush with the adjacent surface. Casting with visible cracks, blow holes or similar blemishes shall be rejected, if the imperfections are located in bearing surfaces or cannot be remedied to the approval of the Engineer.

(vi) Imperfections, which are not located in, bearing surfaces shall be cleaned out, filled with weld metal of the appropriate composition and ground flush.

(vii) All surfaces of major components like top plates, saddle plates, base plates, roller of the bearings shall be machined all over for correct alignment interchangeability, proper fitting etc.

(d) Tolerances

Tolerances for its individual components or of the assembled bearing shall be as shown on the Drawings or subject to the approval of the Engineer.

Unless otherwise specified, the following tolerances shall be maintained:

Diameter of Rollers, Knuckle Pins and Bores

Tolerances on diameter of rollers and all convex surfaces shall conform to IS: 919.

Tolerances on diameter of all concave surfaces shall conform to IS:919.

Height of Bearing

Tolerances on height of any component casting shall not exceed + 0.5 mm. No minus tolerance shall be allowed. The edges of all ribs shall be parallel throughout their length.

Base Plate

Tolerance on length and width of the base plate shall not exceed + 1.0 mm, tolerance on the thickness of the plate shall not exceed + 0.5 mm. No minus tolerance shall be allowed. All rocking, rolling and sliding surfaces shall have a machine smooth finish to 20 micron maximum mean deviation as per IS: 3073.

Casting

No minus tolerance shall be allowed in the thickness of any part of the castings. The edges of all ribs shall be parallel throughout their length.

(e) Installation

General

(i) Bearing shall be placed in the positions as shown on the Drawing with all bearings surfaces in full contact and to the tolerances as specified.

(ii) Roller and rocker bearing shall be placed so that their axles of rotations are horizontal and normal to the direction of movement of the members they support. Upper and lower bearing plates shall be set horizontal in both directions.

(iii) During installation, the bearing shall be pre-set with respect to the bearing axis to account for the movement due to the followings:

- Temperature variation between the average temperature prevailing at the time of installation and the mean design temperature.
- Shrinkage, creep and elastic shortening.

(iv) For girders in gradient, the bearing places shall be placed in a horizontal plane.

Placing

(i) On supporting structures, pockets shall be provided to receive anchor bolts; one side of the pocket beyond the bearing plate. The pocket shall be filled with cement sand mortar of mix 1:1 ratio and the concrete bearing area shall also be finished level by a thin stiff cement sand mortar pad of mix 1:1 ratio (thickness not exceeding 12 mm) just before placing assemblies or bottom plate on the concrete seat.

(ii) In case of pre-cast girders a recess of 6 mm shall be provided on the underside with a level finish for housing the bearing plate. A thin and stiff cement sand mortar mix 1:1 ratio with thickness not exceeding 3 mm shall be provided over the top plate lowering the pre-cast beam in position in order to ensure full and pressure on the plate surface.

(iii) It shall be ensured that while placing the girders, the bearing are in their exact positions as indicated on the approved Drawing and not displaced therefrom.

(iv) All concrete surfaces to be in contact with the mortar shall be thoroughly cleaned and kept saturated with water for a period

not less than 24 hours before placing mortar operations are to be carried out when the surface temperature of the exposed bearing are the minimum practical.

(v) No mortar that is more than 30 minutes old after completion of mixing shall be used.

(vi) After placing and finishing the mortar the bearing shall be checked for position and shims or other temporary supports removed and the mortar made good. If the bearing has moved, bearing or the plate shall be lifted, the mortar removed and the whole procedure repeated.

(vii) Exposed faces of the mortar shall be cured under damp Hessian for 7 days.

(viii) Placing of the bearing and mortar shall only be carried out in the presence of the Engineer.

Checking, cleaning and lubrication

Before erection, each bearing shall be uncrated, disassembled and checked. Any damaged parts shall be made good to the satisfaction of the Engineer.

All bearing with sliding surfaces shall be cleaned and lightly lubricated with an approved lubricant immediately before erection.

(f) Tests and Standard of Acceptance

(i) The materials to be used in the bearings shall conform to the specifications laid down in these Specifications.

(ii) A suitable number of complete bearing as specified by the Engineer shall be tested to 1.25 times the design load. Recovery should be 100 per cent. Contract surfaces shall be examined by illumination source for any defects, cracks, etc. Segmental rollers shall be tested for design movements.

(iii) For large lots (consisting of 12 sets or more), a quality control report shall be submitted as detailed below.

- Unless otherwise agreed upon by the Engineer, the Contractor shall furnish a complete report on the process of quality control. The Engineer may appoint an authorized inspection agency for inspection purpose on his behalf. Such an inspection agency shall also submit reports to the Engineer regarding various tests performed on the bearing or certify the acceptance of the bearings.

- The certificates of all raw materials shall be submitted. If manufacturer's test certificates are not available for the raw materials, the bearing manufacturer shall perform the necessary confirmatory tests as per relevant codes of practice and shall furnish the test results.

- A details quality control system including stage by stage inspection starting from raw materials upto the finished bearing shall be submitted by the Contractor.

- The Engineer shall reserve the right to witness such inspection at manufacturer's work with or without prior permission of the manufacturer. For this, the bearing manufacturer shall have in plant testing facilities.

- In case there is a major discrepancy regarding material, the Engineer shall reject the whole lot of bearings.

- In case minor defects in fabrication, like welding or machining is found in the test bearing before destructive testing and if the test bearing is found to be acceptable after destructive testing, the minor defects in the test bearings shall not be a bar to the acceptance of the entire lot.

(4) Elastomeric Bearing

The term "bearing" in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomer bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and/or rotation of the Superstructure by elastic deformation.

(a) Raw Material

Chloroprene (CR) only shall be used in the manufacture of bearing.

Grades of raw elastomer of proven use in elastomeric bearing, with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110, Skyprene B-5 and Denka S-40 V) shall be used.

No reclaimed rubber or vulcanized wastes or natural rubber shall be used.

The raw elastomeric content of the compound shall not be lower than 60 per cent by its weight. The ash content shall not exceed 5 per cent. (as per tests conducted in accordance with ASTM D-297, sub-section 10).

EPDM and other similar candidate elastomers for bridges bearing use shall not be permitted.

Properties

The elastomer shall conform to properties specified in Table 19.2

	Property	**Unit**	**Test Method, IS Specification Reference**	**Value of the Characteristic Specified**
1.	**Physical Properties**			
1.1	Hardness	IRHD	IS: 3400 (Part 2)	60±5
1.2	Minimum Tensile Strength	N/sq.mm.	IS: 3400 (Part 1)	17
1.3	Minimum Elongation at break	Per cent	IS: 3400 (Part 1)	400
2	**Maximum Compression Set**	Per cent	IS: 3400 (Part 10) duration (h): +0 to 24.2 temperature (^{o} C): 100± 1	35
3	**Accelerated Ageing**		IS: 3400 (Part 4) Duration (h): 70 temperature (^{o} C): 100± 1	
3.1	Max change in hardness	IRHD		+15
3.2	Max change in Tensile strength	Per cent		-15
3.3	Max change in Elongation	Per cent		-40

Shear moulds of the elastomer bearing shall neither be less than 0.80 N/sq.mm nor greater than 1.20 N/sq.mm.

The adhesion strength of elastomer to steel plates determined according to IS: 3400 (Part 14) method A shall not be less than 7 kN/m.

For elastomeric bearing (CR) used in adverse climatic conditions, the following ozone resistance test shall be satisfied:

The ozone resistance of elastomer shall be proved satisfactory when assessed by test according to IS: 3400 (Part 20). The strain, temperature, duration and ozone concentration of the test shall be 20 per cent, 40 ± 1 degree Celsius , 96 h and 50 pphm by volume respectively.

No cracking detected by visual observation at the end of the test shall be considered satisfactory. No specific tests for assessment of low temperature resistance may be deemed necessary.

Note: For use of elastomer in extreme clod climates, the Engineer may specific special grade of low temperature resistant elastomer in conformity with operating ambient temperature resistant elastomer in conformity with operating ambient temperature conditions. The specifications of such special grade elastomer including the tests for low temperature resistance shall be mutually agreed to by the Engineer and the Contractor and are outside the purview of these specifications.

Laminates of mild steel conforming to IS: 2062 shall only be permitted to be used. Use of any other material like fiberglass or similar fabric, as laminates shall not be permitted.

The Contractor's manufacturers of elastomeric bearings shall satisfy the Engineer that they have in-house facilities for testing the elastomer for carrying out the following tests in accordance with the relevant provisions of ASTM D-297.

(a) Identification Polymers	:	to confirm the usages of chloroprene (appendix X-2)
(b) Ash content test	:	to determine the percentage (sub section 34)
(c) Specific gravity test	:	(sub section 15)
(d) Polymer content test	:	(sub section 10)

The Engineer shall invariably get the test (a) performed in his presence or in the presence of his authorized representative to satisfy the requirement. In case of any disputes regarding interpretation of results, the Engineer may carry out test as per ASTM S-3452-78 (Chromatography test) at the manufacturer's cost in a recognized laboratory.

The elastomer specimen to conduct the test shall be obtained from the bearings selected at random for destructive test. Remaining part of the test bearing shall be preserved by the Engineer for any test to be done in future if required.

(b) Fabrication

Bearing with steel laminates shall be cast as a single unit in a mould and vulcanized under heat and pressure.

Casting of elements in separate units and subsequent bonding shall not be permitted, nor shall cutting form large size cast be permitted.

Bearing of similar size to be used in bridge shall be produced by identical process and in one lot as far as practicable. Phased production may only be resorted to when the total number of bearing is large enough.

The mould used shall have standard surface finish adequate to produce bearing free from any surface blemishes.

Steel plates for laminates shall be sand blasted, clean of all mill scales and shall be free from all contaminants prior to bonding by vulcanization. Rusted plates with pitting shall not be used. All edges of plates shall be rounded.

Spaces used in mould to ensure cover and location of laminates shall be of maximum size and number practicable. Any hole at surface or in edge cover shall be filled in subsequently.

Care shall be taken to ensure uniform vulcanizing conditions and homogeneity of elastomer through the surface and body of bearing.

The bearing shall be fabricated with the tolerance specified in Table 19.3.

Table 19.3: Tolerance

S. No.	Item	Tolerance
1.	Overall plan dimensions	0, +6 mm
2.	Total bearing thickness	0, +5 mm
3.	**Parallelism**	
a)	Of top surface of bearing with respect to the bottom surface as datum.	1 in 200
b)	Of one side surface with respect to the other as datum	1 in 100
4.		
a)	Thickness of individual internal layer of elastomer	± 20 percent (max of 2 mm)
b)	Thickness of individual outer layer	-0, +1 mm
5.		
a)	Plan dimensions of laminates	-3 mm +0
b)	Thickness of laminates	± 10 percent
c)	Parallelism of laminate with respect to bearing base of datum.	1 in 100

The vulcanizing equipment/press shall be such that between the platens of press, the pressure and temperature are uniform and capable of being maintained at constant values as required for effecting a uniform vulcanization of the bearing.

The moulding dies utilized for manufacturing the bearing shall be so set inside the platen of the press so that the pressure developed during vulcanization of the product is evenly distributed and the thickness

maintained at all places are within acceptable tolerances limits taking into consideration the shrinkage allowance of vulcanizate.

Before any vulcanizate of any batch of production is used for producing vulcanized bearings, test pieces in the form of standards slab and buttons shall be prepared in accordance with prescribed standards and salient properties tested and recorded regularly against each batch of production to monitor the quality of the products.

(c) Acceptance Specification

The acceptance specifications for elastomeric bearing shall conform to IRC: 83: Standard Specification and code of Practice for Road Bridges, Sections 9, Part 2 Elastomeric Bearings.

(d) Certification and Marking

Bearing shall be transported to bridge site after final acceptance by Engineer and shall be accompanied by an authenticated copy of the certificate to that effect.

An information card giving following details for the bearings, duly certificated by the manufacturer shall also be appended:

Name of manufacturer
Date of manufacturer
Elastomer grade used
Bearing dimensions
Production batch no.
Acceptance lot no.
Date of testing
Explanation of marking used on the bearing

All bearing shall have suitable index marking identifying the information. The marking shall be made in indelible ink or flexible paint and shall be visible after installation. The top of the bearing and direction of installation shall be indicated.

(e) Storage and Handling

Each elastomeric bearing shall be clearly labeled and marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearing during transport and handling prior to and during installation.

(f) Installation

Installation of multiple bearings one behind the other on a single line of support shall be identical dimensions.

Bearings shall be placed between true horizontal surfaces (maximum tolerance 0.2 per cent perpendicular to the load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance ± 3 mm).

Concrete surfaces shall be free from local irregularities (maximum tolerance ± 1 mm in height)

For cast-in-place concrete construction of superstructure, where bearings are installed prior to its concreting the forms around the bearings shall be soft enough for easy removal. Forms shall also fit the bearings snugly and prevent any leakage of mortar grout. Any mortar contaminating the bearings during concreting shall be completely removed before setting.

For pre-cast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specifications for adhesive material, workmanship and control shall be approved by the Engineer. Care shall be taken to guard against faulty application and consequent behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearing against displacement for the purpose of design.

As a measure of ample safety against accidental displacement, the bearings shall be placed in a recess as shown in Fig. 9 of IRC (Part 2).

(g) Seating of Elastomeric Bearing on a Non-Horizontal Plane

Installation of elastomeric bearing on a Non-Horizontal Plane shall be as follows:

(i) Elastomeric bearing shall be delivered with MS backing plate fastened to the bearing from the manufacturer.

(ii) Template of 6 mm M.S. plate and of size same as bearing holding base plate with matching holes for the anchor screws shall be used. Anchors shall be fitted to the templates with the anchor screw but with MS washers in place of elastomer washers. The above template assembly shall be fitted in the formwork at its proper location and in a vertical plane.

(iii) After casting of the pedestal and removal of the formwork, the template shall be removed.

Installation with face plate and without template in-situ casting

(i) The sub-assembly of elastomeric bearing with the MS backing plate shall be fitted to the embedded anchors with anchor screw and elastomeric washers replacing the steel washer.

(ii) A clearance shall be maintained between the stainless steel face of the elastomeric bearing and that of the vertical face of the face plate with stainless steel top installed on the projection below the soffit. This shall be achieved by inserting removal steel sheeting of thickness as per the Drawing, during preparation of the formwork before casting of the superstructure.

Installation with face plate and with template in-situ-casting

(i) Template of 6 mm MS plate and size same as face plate with stainless steel top and matching holes for the anchor screws shall be used. Anchors shall be fitted to the templates with the anchor screws but with MS washers in place of elastomer washers. Separate screws may be used in case of inconvenience of in the length of original anchor screws. The above template assembly shall be fitted in the formwork for the super-structure at its proper location and in a vertical plane.

(ii) After removal of the super-structure formwork, the template shall be removed.

(iii) The face plate with the required thickness of pack plate shall be loosely fitted to the anchors embedded in the projection below the superstructure, with elastomer washers and anchor screws.

(iv) The sub-assembly of elastomeric bearing with the MS backing plate shall be fitted to the embedded anchors in the pedestal with anchor screws and elastomeric washers replacing the steel washers this time.

(v) The required clearance between the stainless steel face of the elastomeric bearing and that of the vertical face plate installed on the projection below the soffit shall be checked. After adjustment of the required working clearance the small gap between the vertical face of the projection below the soffit and the back of the face (plate with pack plates, if any) shall be grouted with epoxy grout.

(5) Special Bearings

(A) Special bearing shall be those type of bearings which shall be also designed for other than usual loads and functions.

(B) Materials

All materials shall be original, unused or non-re-cycled conforming to relevant specifications:

(i) Cast Steel, Mild Steel, Stainless Steel shall conform to Sub-clause 1902 3 (a)

(ii) Copolymer poly Tetra Fluora Ethylene (PTFE) unfilled quality shall have required properties as per BS:5400 and thickness shall be as specified.

(C) Type of Special Bearings

(1) Spherical Bearing

The bearing shall consist of the following parts:

Bottom Plate

A bottom plate with concave surface shall be integrally cast of circular/square plate. The bottom plate shall be connected to the sub-structure by means tight fitted anchor bolts, which shall be embedded in concrete. The material of bottom plate shall be cast steel.

Pure unfilled quality dimpled PTFE of specified thickness shall be provided on top of concave surface of bottom plate in order to allow smooth rotation.

Saddle Plate

A saddle plate with square/circular/rectangular top and convex surface at bottom shall be placed in the concave surface of bottom plate. The radius of curvature of the convex bottom of the saddle plate shall be slightly less than that of concave top surface of the bottom plate to ensure sufficient contact over a small area. Rotation along all axes shall be permitted along the contract surface of the saddle plate and the bottom plate. Pure unfilled quality dimpled PTFE sheet shall be recessed to specified depth of recess over the top of saddle plate. Suitable elastomeric seal shall be provided on the saddle plate to prevent ingress of dirt and moisture. The material of saddle plate shall be cast steel.

Top Plate

The top plate shall have stainless steel plate welded to its bottom which shall be slide over PTEF. The assembly shall be connected to the superstructure by tight fitted anchor bolts. Translatory movements along longitudinal axis of bridge shall be accommodated at the PTFE/Stainless steel-sliding surface. The material of top plate shall be cast steel.

Guide Plate

Guide plate shall be welded to saddle plate so to permit only longitudinal movement. The material of guide plates should be cast steel.

(a) Acceptance test on Spherical Bearings

(i) All bearings shall be checked for overall dimensions

(ii) All bearings shall be load tested to 1.25 times dexign vertical load

(iii) A pair of bearings selected at random shall undergo testing in order to determine coefficient to friction, which shall be less than 0.05.

(iv) Two bearings selected at random shall be tested for permissible rotation.

(2) Pin Bearing

Pin bearing shall ensure fixity by arresting translatory movement. The pin bearing shall not take any vertical load. It shall take care of the longitudinal horizontal force of the entire superstructure unit as well as transverse horizontal force developed at the fixed end.

A pin bearing shall consist of a height structural built-up column embedded in pier cap and the protruding length inside soffit of deck shall have rocker plates on all four sides, which permit rotation.

The sliding spherical and pin bearing shall conform to BS: 5400, Parts 9.1 and 9.2 and all relevant clauses of this specification. Bearings shall be guaranteed for design loads and movements. The term bearing shall include the entire assembly covering all the accessories required for operation, erection and dismantling for replacement. All bearings shall be

of replaceable type. These bearings shall be based on their design to the mentioned specifications.

(a) Seating of Pin Bearing

(i) Backing plate with studs welded on the face opposite to the seating shall be delivered by the Contractor.

(ii) This packing plate shall be accurately positioned on the reinforcement grid of the pedestal and leveled.

(iii) Studs shall be track welded/tied to the reinforcement to keep the backing plate in proper location during casting.

(iv) Depth of embedment of the backing plate in the concrete shall be as per relevant Drawing.

(v) The round base of the pot (bottom) of the pin bearing assembly shall be connected to the backing plates by anchor screws after concreting of pier cap/pedestal.

(vi) In order to ensure successful transfer of large horizontal forces to be resisted by the Pin bearing. Care shall be taken in detailing the reinforcement in the sub-structure and the super-structure adjacent to the studs in the backing plate.

(b) Acceptance Test on Pin Bearings

(i) All bearings shall be checked for overall dimensions

(ii) All bearings shall be load tested.

(3) Pin Bearing

(a) General

Pot type bearings shall consist of a metal piston supported by a disc or unreinforced elastomer confined with a metal cylinder to take care of rotation. The pot bearings shall consist of cast steel assemblies or fabricated structural steel assemblies.

Provisions of IRC-83 (Part I) shall be applicable for all metallic elements. Provisions of IRC: 83 (Part II) shall be applicable for all elastomer elements. When any item are not covered by

IRC: 83 (Part 1 and 2) the same shall be as per guidelines given hereunder and BS: 5400 (Sections 9.1 and 9.2), except that no natural rubber shall be permitted. If there is any conflict between BS and IRC, the provisions of IRC shall be guiding.

Combination bearing using any judicious combination and sliding element shall be permitted. As for example.

Name	Rotation Element	Sliding Element	Generally for
Plot Elastomer Pot PTFE	Plot Elastomer Pot PTFE	None None* PTFE-SS**	Vertical Load Horizontal Buffer Vertical Load and Horizontal Load
Spherical	Spherical	PTFE-SS**	Vertical Load and Horizontal Load
Knuckle PTFE Elastomer SS**	Knuckle Elastomer	PTFE-SS** SS-SS	Transverse Guide Transverse Guide

* Elastomer shall permit movement by shear
** Stainless Steel

(b) Fabrication

(i) The surface matting with the PTFE in the sliding pair shall be corrosion resistant stainless steel. The stainless steel shall overlap the PTFE after full movement on all sides. If stainless steel sheet is used, it shall be bonded by continuous welding along the edges. The surface shall be prepared by thorough clearing to remove grease, dust or any other foreign substance.

(ii) PTFE moulder sheets of the sliding pair shall be located by confinement assisted by banding. Confined PTFE shall be recessed into the metal backing plate. The shoulder of the recess shall be sharp and square to restrict the flow of PTFE.

(iii) The thickness of the PTFE shall not be less than 4.5 mm with projection above the recess not exceeding 2.0 mm. When the piston is subjected to tilting, the seal shall slide along the wall and alter its shape according to the angle of tilt. At the same time it shall be sufficiently rigid to bridge the gap between the piston and the wall of the pot. However, the percentage of plan area of the lubrication activities to the gross area shall not exceed 25 percent. The depth of the cavity shall not exceed 2.0 mm.

(iv) The diameter to thickness ratio of the confined elastomer shall not exceed 15. The surface of the confined elastomer shall be smooth.

(v) A seal shall be provided to prevent extrusion of the confined elastomer between the piston and the post wall. The seal shall stay functional under the loads and rotations acting on it. Additional seal shall be provided to prevent entry of dust into the pot. Sealing rings for pot bearings shall be fabricated from stainless steel. When the piston is subjected to tilting, the seal must slide along the wall and alter its shape according to the angle of tilt. At the same time, it must be sufficiently rigid to bridge the gap between the piston and the wall of the pot.

(vi) The hardness of the piston and pot wall at their contact region shall be minimum 350 BHN to reduce wear. The surface finish of the pot base in contact with the confined elastomer shall be smooth.

(vii) All bearing shall be installed with anchor and anchor screws or some similar device such that while replacing, the bearings can be removed with minimum lifting of the superstructure.

(viii) The external surface of the assemblies shall be completely cleaned by sand blasting. After sand blasting, dust shall be removed form the surface using clean and dry compressed air of a clean brush after which suitable coating shall be applied.

(ix) Pot bearings including all parts as shown on the Drawings shall be fully shop assembled at the manufacturer's works to ensure proper fitting of all parts.

(c) Materials

(i) Steel

- Structural steel shall confirm to IS:2062 as applicable
- Cast steel shall conform to Gr 280-520W of IS 0.3 to 0.5 percent copper may be added to increase the corrosion resistance properties.
- Stainless steel shall conform to AISI:304 or X04Cr 18NilO of IS:6911 for ordinary applications. For applications with

adverse/corrosive environment, the stainless steel conform to AISI; 316L or O2Cr17Nil2Mo2 of IS:6911.

(ii) PTFE

PTFE (poly tetra fluoro ethylene) shall be of unfilled pure virgin quality. It shall be free sintered. The mechanical properties of unfilled PTFE shall comply with Grade A of BS:3784

(iii) Elastomer

The confined elastomer inside pot shall have the following properties.

- Hardness IRHD IS:3400 (Part 2)

  50+5

- Min. tensile Strength Mpa IS:3400 (Part 1)

  15.5

- Min. elongation at break, shall be as per Table 19.2 max compression set and "Properties of Elastomer" accelerated aging.

Other details shall be as per Sub-clause 1902 (5) (a).

(d) Workmanship

(i) Welding

All welding shall conform to IS:9595 with electrodes of suitable grade as per IS:814. Preheating and post weld stress relieving shall be done as per IS:9595.

(ii) Cast Steel Assemblies

Cast steel for pot-bearing assemblies shall conform to requirements of relevant IS. Casting shall be true to the forms and dimensions shown on the Drawings, and shall be free from pouring faults, sponginess, cracks, blow holes and other defects affecting their appearance or their strength, Warped or distorted casting shall not be accepted. Exposed surface shall be smooth and dense.

All irregularities, fins or risers shall be ground off flush with the adjacent surface. Castings with visible cracks, blow holes or similar blemishes shall be rejected if the imperfections are located on bearing surfaces or cannot be remedied to the satisfaction of the Engineer.

Imperfections, which are not located on, bearing surfaces shall be cleaned out filled with weld metal of the appropriate composition and ground flush with adjacent surfaces.

(iii) Structural Steel Assemblies

Defects arising from the fabrication of the steel shall be inspected by the Engineer, who shall decide whether the materials may be repaired by the Contractor or will be rejected. The cost of repairs or replacement shall be borne by the Contractor.

All plates shall be flat and rolled bars. Straightening shall be done by methods, which shall not damage the material. Sharp kinks and bends shall be the cause for rejection.

Steel may be flame cut to shape and length so that a regular surface, free from excessive gouges and striations is obtained. Flame cutting by hand shall be done only with the approval of the Engineer.

Exposed corners shall be machined or ground.

(e) Tolerance

(i) Plan dimensions : -0 to +5 mm

(ii) Overall height : -0 to +3 mm

(iii) Height of elastomer : ± 5 percent

(iv) Height of any steel compmponent

- Machined : -0 to + 1mm
- Unmachined : Class 2 of IS:4897

(v) Stainless steel sliding surface

- Flatness : 0.0004, where L is the length in direction of measurement

- Surface finish : Ra, ≤ 0.25 pm s per IS:3073.

(f) Painting

(i) All non-working surfaces shall be coated with two coats of epoxy primer and one or more coat each of epoxy intermediate and finish, total thickness ≤ 0.150 pm or any other painting scheme as approved by the Engineer.

(ii) Silicon grease shall be applied at the PTFE/SS interface after testing.

(iii) Anchor sleeves shall be cement coated at the manufacturer works.

(g) Test

(i) Raw Materials

Necessary test certificates for all raw materials shall be furnished by manufacturers. Reference shall also be made to Sub-clause 1902 (5) a) for tests on elastomers.

(ii) Test on Casting

Tests specified in IS: 1030 shall be performed. Casting shall be ultrasonically tested and certificates submitted. Quality level of castings shall be level 3 as per IS:9565.

(iii) Test on Welding

All welding shall be tested by Dye Penetration Method. Butt welding shall be tested by Ultrasonic Method. The manufacturer shall certify soundness of welding.

(iv) Acceptance Test on Bearing

- Bearings shall be checked for overall dimensions.
- All bearings shall be load tested to 1.25 times maximum design capacity including seismic force. Bearings tested at higher loads shall not be used.
- All pair of bearings selected at random will undergo testing in order to determine the coefficient of friction “u”. The coefficient of friction shall be ≤ at 0.05 the design load.

- Two bearings selected at random shall be tested for permissible rotation.

(h) Installation of POT -cum- PTFE Bearings

(i) General

- Care shall be taken during installation of the bearings to permit their correct functioning in accordance with the design scheme.

- To prevent contamination, dismantling of the bearings at site shall not be done.

- The load shall be transferred onto the bearings only when the bedding material has developed sufficient strength. The props for the formwork shall only be removed after lapse of appropriate time. In special cases, suitable devices like jacks, etc can ensure this.

- Temporary clamps and shims (introduced to maintain working clearance) shall be removed at an appropriate time, before the bearing is required to permit movement.

- Permitted installation tolerance of the bearing from plane of sliding shall be maintained.

- Cement based non-shrink grout with air releasing additive and epoxy based grout, whichever is specified shall be first tried at the site. For the proprietary grout mixes, appropriate instructions from the manufacturer shall be followed specially with regard to the following:

  - Preparation: concrete cleaning, roughening, pre-soaking etc.

  - Forms: sturdiness, leak proofing, shape, header tunnel vents etc.

  - Bearing Base: cleaning etc

  - Placement: mixing, consistency, time period, finishing etc.

  - Protection: curing, ambient temperature etc.

(ii) In-situ Casting of Superstructure

- Formwork around the bearing shall be carefully sealed to prevent leakage.

- Sliding plates shall be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under the weight of wet concrete.

- Bearings shall be protected during concreting operation. Any mortar contaminating the bearing shall be completely removed before it sets.

(i) Seating of Bearing

(i) Using Template

- Template with required rigidity and matching holes corresponding to the base of the bearing shall be used.

- All the anchors shall be fitted to the lower face of the template using the anchor screws but with steel washer replacing the elastomer washers. Separate screws may be used in case of inconvenience in the length of the original anchor screws.

- The template assembly shall be located with regard to level and alignment. It shall be ensured that the top of the anchors lies in a horizontal plane at the required elevation. The anchors shall be tied/welded to reinforcements to avoid displacement during concreting.

- Concreting of the pedestal/pier cap shall be done to a level leaving a gap of 25-50 mm below the template.

- The template and steel washers shall be removed prior to placement of the bearing assembly with temporary clamps. The bearing assembly shall be fitted to the anchors with the help of anchor screws and elastomer washers. Level at the bearing shall be checked.

- The gap below the bearing assembly shall be grouted with cement based grout.

(ii) Without Template with Gap

- Pockets commensurate with the sizes of the anchors shall be kept in pedestals during concreting of the same. The pedestal shall be cast approximately 25 mm short of the required finished level.

- Anchors shall be fitted to the bearing bottom with elastomer washers and anchors screws. The bearing assembly shall be seated in the location on steel chair/packs. The anchors fitted below the bearing shall go into pockets in the bed block. Level and alignment of the bearing shall be checked. It shall be ensured that the bearing sits in a horizontal plane.

- The gap below the bearing assembly including anchor pockets shall be grouted with cement based grout.

(iii) Without Template without Gap

Elongated pockets commensurate with the sizes of the anchors shall be kept in pedestals during concreting of the same. The geometry and location of the anchor pockets (with tapered funnel extension, if required) shall be such that after placement of the bearing the pockets can be successfully grouted. The pedestal shall be cast 5 mm – 15 mm short of the required finished level. The required level shall be achieved by chipping before placement of the bearing. Careful control shall be exercised to cast at the exact finished level or 1 mm – 3 mm down from the required finished level.

(iv) Seating of bearings shall be as per manufacture's instructions

Inspection and Testing

Where any patents are used, the manufacturer's certificate with test proofs shall be submitted along with the design and got approved by the Engineer before their use in work.

Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

(6) Measurement

Bearings shall be measured in number inclusive of all axlliary and incidental works.

(7) Payment

The bearing shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 and for all costs required to complete the work as per these Specifications.

SECTION 2000 – CONCRETE FOR STRUCTURES

SECTION 2000 – CONCRETE FOR STRUCTURES

2001. SCOPE

This Section covers the materials, design of mixes, transport, placing, compaction and curing of concrete and mortar required in the works. It also covers reinforcement for concrete.

2002. DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced, pre-stressed or unreinforced concrete construction which is subject to stress.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling foundations and similar purpose where it is not subjected to significant stress.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc. and also to the volume which has to be filled. Pours in vertical succession are referred to as lifts.

2003. MATERIAL FOR CONCRETE

(1) General

The Contractor shall submit to the Engineer full details of all materials which he purposes to use for making concrete. No concrete shall be placed in the works until the Engineer has approved the materials of which it is composed. In accordance with Clause 603, approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

(2) Cement

Cement shall comply with the requirements of Clause 614.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level not less than 30 cm and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked so as to reduce air circulation with min gap of 500 mm from outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. Stack of cement bags shall not exceed 8 bags in height. Different types of cement in bags shall be clearly distinguished by visible marking and shall be stored in separate stacks.

Cement form broken bags shall not be used in the works. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weather proof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

All cement for any one structure shall be from the same source as far as possible.

All cement used in the works shall be tested by the manufacturer. The manufacturer shall provide the results of tests as given in Table 20.1 and 20.2 for each supply and for the last six months of his production. The Contractor shall supply two copies of each certificate to the Engineer.

Table 20.1: Test Results for Chemical Composition of Cement

Compounds %		Mean	Min	Max.	Standard deviation
Lime	CaO				
Silica	SiO_2				
Alumina	Al_2O_3				
Iron Oxide	Fe_2O_3				
Magnesia	MgO				
Sulphur Trioxide	So_3				
Soda, potash	Na_2O, K_2O				

Table 20.2: Test Results for Physical Properties of Cement

Characteristics	Requirements	Nominal	Mean	Min.	Max	St. Dev
Fineness, M^2/KG: (by Blaine's Air Permeability Method)	225					
Minimum Setting time (initial), minutes	45					
Maximum Setting time (final), minutes	600					
Soundness (by Le Chatelie method) mm, maximum	10					
Minimum Average Compressive Strength of three mortar cubes, (N/mm^2)						
3 days	16,27*					
7 days	22,37*					
28 days	33,53*					

** denotes the requirements of High Strength Protland Cement*

Each set of tests carried out by the manufacturer on samples taken from cement which is subsequently to site shall relate to no more than one day's output of each cement plant.

The Contractor shall constitute each type of cement and not less than one samples for every 200 tonnes or part of it, representative samples to be tested when instructed by the Engineer in a laboratory acceptable to him, in case of the concrete mixes do not comply with the requirements of this Specification.

Cement which is stored on site for longer than one month shall be tested in such laboratory for every 200 tonnes or part thereof and at monthly intervals thereafter.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and the cement used in the works and shall provide the Engineer with two copies thereof.

(3) Fine Aggregate

Fine aggregate shall be clean hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with IS 383. All the material shall pass through a 4.75 mm IS sieve and the grading shall be in accordance with IS 383. In order to achieve an acceptable grading, it may be necessary to blend materials from more than one source.

The deviation from the initial fineness modulus shall be no more than ± 0.30 for ordinary concrete and ± 0.20 for high quality concrete.

However, in respect of the presence of deleterious materials the fine aggregate shall not contain iron pyrites, iron oxides, mica, shale, coal or other laminar soft or porous materials or organic matter unless the Contractor can show by comparative tests on finished concrete as set out in Clause 617 and as per the direction of the Engineer, that presence of such materials does not affect the properties of the concrete.

(4) Coarse Aggregate

Coarse aggregate shall be clean hard and durable crushed rock, crushed gravel or natural gravel corresponding to the following classes:

Class A: Aggregate shall consist of crushed igneous or quartzite rock from an approved source.

Class B: Aggregate shall consist of crushed quarry rock other than class A from an approved source.

Class C: Aggregate shall consist of natural or partly crushed gravel pebbles obtained from an approved gravel deposit. It may contain a quantity of material obtained from crushing the oversize stone in the deposit provide such material is uniformly mixed with the natural uncrushed particles.

Class D: Aggregate shall consist entirely of crushed gravel. The crushed gravel shall be produce from material retained on a standard sieve having an opening at least twice as large as the maximum size of aggregate particle specified.

Class E: Aggregate shall consist an artificial mixture of any of the above classes of aggregate. The aggregate use of Class E aggregate and the relative proportions of the constituent materials shall be approved by the Engineer.

Coarse aggregate shall be supplied in the nominal size called for in the contract and shall be of the grading as single sized aggregate or graded aggregate of nominal size 40 mm, 20 mm, 12.5 mm and 10 mm in accordance with IS 383.

Other properties shall be set out below:

Flakiness Index: When tested in accordance with IS 2386 Part 1, the Flakiness Index of the coarse aggregate shall be as set out hereunder:

For ordinary concrete	: not more than 25
For high quality concrete	: not more than 15

If the Flakiness Index of the coarse aggregate varies by more than five units from the average value of the aggregate used in the approved trial mix, then a new set of trial mixes shall be carried out if the workability of the mixes has been adversely affected by such variation.

Water Absorption: the aggregate shall not have a water absorption of more than 2 per cent when tested as set out in IS 2386 Part 3.

Los Angeles Abrasion (LAA): The aggregate shall have LAA not more than 45% for ordinary concrete, and not more than 35% for high quality concrete, when tested in accordance with IS 2386 Part 4.

Aggregate Crushing Value (ACV): The aggregate shall have ACV not more than 30% for pavement structure and not more than 45% for other structure when tested in accordance with IS 2486 Part 4.

Alkali Aggregate Reactivity: The aggregate shall comply with IS 383/3.2 notes when tested in accordance with IS 386 Part 7.

(5) Testing Aggregate

(a) Acceptance Testing

The Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposed to use in the works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labeled to show its origin and shall be accompanied by all information called for in IS 2386 Part 1 to 8.

Tests to determine compliance of the aggregates with the requirements of sub-clause 2003 (3) and (4) shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall be made in the presence of the Contractor and the Engineer. Acceptance of the material shall be based on the results of such tests.

All the materials shall be accepted if the results of not less than three consecutive sets of test executed in accordance with IS 2386 (Part 1-8) show compliance with the Sub-clause 2003 (3) and (4).

(b) Compliance Testing/Process Control Testing

The Contractor shall carry out routine testing of aggregate for compliance with the Specification during the period that concrete is being produced for the works. The tests set out below shall be

performed on aggregate from each separate source on the basis of one set of tests for each day on which aggregate are delivered to site provide that the set of tests shall represent not more than 100 tonnes of fine aggregate and not more than 250 tonnes of coarse aggregate, and provided also that the aggregates are of uniform quality.

Grading	:	IS 2386 Part 1
Silt, Clay Contents and Organic Impurities	:	IS 2386 Part2

If the aggregate from any source is variable, the frequency of testing shall be increased as instructed by the Engineer.

In addition to the above routine tests, the Contractor shall carry out the following tests at the stated frequencies.

Chloride Content: As frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

Sulphate Content and Alkali Aggregate Reactivity: As frequently as may be required according to the variability of sulphate content and alkali reactivity assessed from the laboratory test carried out during the concrete mix design.

(6) Delivery and Storage of Aggregate

Aggregate shall be delivered to site in clean and suitable vehicles. Different type or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that the contamination of aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregate shall be arranged in such a way that drying out in hot weather is prevented in order to avoid fluctuations in water content. Storage of fine aggregates shall be arranged in such way that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

(7) Water for Concrete Mortar

Water shall be clean and free from harmful matter and shall comply with the requirements of IS 456.

Brackish water containing more than 1000 ppm chloride ion 2000 ppm sulphate ion shall not be used for mixing or curing concrete.

The Contractor shall carry out tests in compliance with IS 456 to establish compliance with Specifications.

(8) Admixture

(a) General

The use of admixtures in concrete may be required under the contract to promote special properties in the finished concrete or may be proposed by the Contractor to assist him in compliance with the Specification.

In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it in the mix. The information provided shall include:

(i) The typical dosage, the method of dosing, and the detrimental effects of an excess or deficiency in the dosage.

(ii) The chemical names of the main active ingredients in the admixture.

(iii) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture.

(iv) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so the extent to which it does so.

(v) Details of previous uses of the admixture in Nepal.

The chloride ion content of any admixture shall not exceed 1 per cent by weight of the admixture nor 0.02 per cent by weight of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Engineer.

Calcium chloride or admixtures containing calcium chloride shall not be used in prestressed concrete.

Admixtures may be supplied as liquid or as powder. They shall be stored in sealed and undamaged containers in a dry, cool place. Admixtures shall be dispensed in liquid form and dispensers shall be of sufficient capacity to measure at one time the full quantity required for each batch.

(b) Workability Agents

Workability agents shall comply with BS 5075 and shall not have any adverse effect on the properties of the concrete.

2004. THE DESIGN OF CONCRETE MIXES

(1) Classes of Concrete

The classes of structural concrete to be used in the works shall be as shown on the Drawing and designated in Table 20.3, in which the class designation includes two figures. The first figures indicates the characteristic strength f_{ck} at 28 days expressed in N/mm^2 and the second figure is the maximal nominal size of aggregate in the mix expressed in millimeters. Letter M in the class designation stands for Mix, letter SM stand for Special Mix.

Consistence of the mix, assessed through the Slump Test where the slump is measured in millimeters, is designate as follows:

S : Stiff consistence, for slump ≤ 40

P : Plastic consistence, for slump >40 and ≤ 90

VP: Very Plastic consistence, for slump >90 and ≤ 150

F: Flowing consistence for slump >150

Table 20.3: Concrete Classes and Strength

Classes of concrete	Consi st-ence	Type of uses	Characteristic Strength f_{ck} (N/mm^2)	Maximum Nominal Size of Aggregate mm	Trial mixes Minimal Target Strength $f_{ck}=1.1f_{ck}$ (N/mm^2)	Early works test cubes	
						Any one result (aver. of 3 cubes) (N/mm^2)	Average of 3 consecutive results (N/mm^2)
M 10/75	S	Ordinary	10	75	11	10	14
M 10/40	S	Ordinary	10	40	11	10	14
M 15/20	S	Ordinary	15	20	16.5	15	19
M 15/40	S	Ordinary	15	40	16.5	15	19
M 20/20	S	Ordinary	20	20	22	20	24
M 20/40	S	Ordinary	20	40	22	20	24
M 25/20	S	Ordinary	25	20	27.5	25	29
M 25/40	S	Ordinary	25	40	27.5	25	29
M 30/40	S	High Quality	30	40	33	30	34
M 30/20	P	High Quality	30	20	33	30	34
M 30/12	P	High Quality	30	12	33	30	34
M 35/40	P	High Quality	35	40	38.5	35	39
M 35/20	P	High Quality	35	20	38.5	35	39
M 40/20	P	High Quality	40	20	44	40	44

M 45/20	P	High Quality	45	20	49.5	45	49
M 50/20	P	High Quality	50	20	55	50	54
SM 30/40	VP	Underwater	30	40	33	30	34
SM 30/20	VP	Underwater	30	20	33	30	34
SM 30/20	F	Bored Piles	30	20	33	30	34
SM 40/20	S	Precast Piles	40	20	44	40	44
SM 45/20	S	Post-tensioned Girders	45	20	49.5	45	49

(2) Design of Proposed Mixes

Concrete mixes shall comply with Clause 617.

The contractor shall design all the concrete mixes called for in the Drawing using the ingredients which have been approved by the Engineer in accordance with Clause 2003 and in compliance with the following requirements:

(a) The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size.

(b) The cement content shall be such to achieve the strength called for in Table 20.3 but in any case not less than the minimum necessary as shown in Table 20.4.

(c) The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.

(d) The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than 0.5 for classes of concrete from M20 to M50 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may in certain cases require the inclusion of a workability agent in the mix.

Table 20.4: Minimum Cement Content

Classes of concrete	Minimum cement content in kg m3 of compacted concrete		
	Moderate exposure	Intermediate exposure	Severe exposure
M 10/75, M 10/40	125	150	175
M 15/40, M 15/20	150	200	225
M 20/40, M 20/20	250	300	325
M 25/20, M 25/40	300	325	350

M 30/40, M 30/20 M 30/12 M 35/40, M 35/20	325	350	375
M 40/20, M 45/20, M 50/20	375	400	425
SM 30/20, SM 30/40	400	400	425
SM 40/20, SM 45/20	425	425	450

Note: The minimum cement contents shown in the above table are required in order to achieve impermeability and durability. In order to meet the strength requirements in the Specification higher contents may be required.

The categories applicable to the works are based on the factors listed hereunder:

Moderate exposure	:	surface sheltered from severe rain, buried Concrete
Intermediate exposure	:	Surface exposed to severe rain; alternate welting and drying; traffic; corrosive fumes; heavy condensation.
Severe exposure	:	Surface exposed to water having a pH of 4.5 or less, ground water containing sulphates.

(3) Laboratory Trial Mixes

For each mix of concrete for which the Contractor has proposed a design, he shall prepare the number of concrete batches specified hereunder:

Nominal composition : 3 separate batches

Modified compositions, the quantities of other constituents being unchanged:

Water	:	+10%	1 batch
Water	:	-10%	1 batch
Cement	:	+15%	1 batch
Cement	:	-15%	1 batch

Samples shall be taken from each batch and the following action taken, all in accordance with BS 1881:

(a) The slump of the concrete shall be determined

(b) Six tests cubes shall be cast from each batch. In the case of concrete having a maximum aggregate size of 20 mm, 150 mm cubes shall be used. In the case of concrete containing lager aggregate, 200 mm cubes shall be used and in addition any pieces of aggregate retained on a 50 mm IS sieve shall be removed form the mixed concrete before casting the cubes.

(c) The density of all the cubes shall be determined before the strength tests are carried out.

(d) All faces shall be perpendicular to each other.

(e) Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.

(*) For "Smaller Contracts Works", the following composition are suggested as a starting basis for the Laboratory trials for one m3 of concrete.

Concrete Class	Characteristic Strength N/mm2	Cement (kg)	Total aggregate (kg)	Fine aggr./ Total aggr. (%)	Water (max) (lit.)	Wrkability
M 15/40 M 15/20	15	250	1900	35-45	160	Stiff-Plastic
M 20/20	20	300	1875	35-45	165-170	Stiff
M 30/40	30	350	1825	35-45	170	Stiff
M 30/20	30	350	1825	35-45	175	Plastic
M 35/20	35	350	1825	35-45	175	Plastic

A "result" being the average strength of the three cubes from one batch, the average of the three results form tests at 28 days for the nominal composition shall not be less than the Minimal Target Strength shown in Table 20.3.

One result from the modified compositions shall not be less than the nominal strength as shown on Table 20.3.

(4) Site Trials

At least six weeks before commencing placement of concrete in the permanent works, site trials shall be prepared for each class of concrete specified.

For each mix of concrete for which the Contractor has proposed a design and successfully tested in Laboratory, he shall prepare three separate batches specified hereunder using the materials which have been approved for use in the works and the mixing plant which he propose to use for the works. The volume of each batch shall be the capacity of the concrete mixer proposed for full production.

Samples shall be taken from each batch and the action taken similar to the above Sub-clause 2004 (3) (a) to (e).

The average of the three results of tests at 28 days shall not be less than the Minimal Target Strength shown in Table 20.3.

The Contractor shall also carry out tests to determine the drying shrinkage of the concrete unless otherwise directed by the Engineer.

Based on the results of the tests on the Laboratory trial and site trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, and the results of the tests on the trial mixes.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the works without the written consent of the Engineer.

(5) Quality control of Concrete Production

(a) Sampling

For each class of concrete in production at each plant for use in the works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Engineer, all in accordance with the sampling procedures described in BS 1881 and with the further requirements set out below.

Six 150 mm or 200 mm cubes as appropriate shall be made from each sample and shall be cured and tested in accordance with BS 1881 three at seven days and the other three at 28 days. Where information samples are required, such as for post tensioning operations, three additional cubes shall be made.

The minimum frequency of sampling of concrete of each grade shall be as following:

For 1-5 m^3 quantity of work - 1 no. of sample

For 5-20 m^3 quantity of work - 2 no. of sample

For 20 m^3 and more quantity of work - 3 no. of sample plus one additional for each 20 m^3 or part thereof.

At least one sample shall be taken from each shifts of work.

Until compliance with the Specification has been established the frequency of sampling shall be three times that stated above and not less than 3 samples/day for each class of concrete in production at each plant or such lower frequency as may be instructed by the Engineer.

(b) Testing

(i) The slump of the concrete shall be determined for each batch from which samples are taken and in addition for other batches at the point of production and deposition or at the frequency instructed by the Engineer.

The slump of concrete in any batch shall not differ from the value established by the trial mixes by more than 25 mm or one third of the value whichever is the less.

(ii) The air content of air entrained concrete in any batch shall be within 1.5 times of the required value and the average value of four consecutive measurements shall be within the required value expressed as a percentage of the volume of freshly mixed concrete.

(iii) Early Works: Until such times as sufficient test results are available to apply the method of control described in (iv) below, the compressive strength of the concrete at 28 days shall be such that no result (average of 3 cubes) is less than the characteristic strength f_{ck} as shown in Table 20.3 under the heading "early works test cubes" and also that the average of three consecutive results in not less than f_{ck} +4 as shown in Table 20.3 under the same heading.

The 7-day cube result may be used as an early strength indicator, at the discretion of the Engineer.

(iv) When at least 20 consecutive results on tested batches are available for any class of concrete mixed in any one plant, no single result shall be less than f_{ck} -4 (N/mm^2) and also the average of any group of three consecutive results shall not be less than f_{ck} +4 (N/mm^2).

In addition the Coefficient of Variation shall be less than the figure given below:

Number of Batches	**Maximum coefficient of variation**	
	Ordinary concrete	**High quality concrete**
After 20 tested batches	18%	15%
After 50 tested batches	15%	12%

$$\textit{Where the Coefficient of Variation} = \frac{\textit{Standard Deviation of the results}}{\textit{Average Value of the results}}$$

(v) Failure to comply with requirements:

If any one result in a group of three consecutive results is less than f_{ck} -4 (N/mm^2), but the other results of group satisfy the strength requirement, then only the batch from which the failed result was obtained shall be deemed not to comply with the Specification.

If the average strength of the group is less than the strength requirement then all the batches between those represented by the first and the last result shall be deemed not to comply with the Specification, and the Contractor shall immediately adjust the production procedure or the mix design subject to the agreement of the Engineer to restore compliance with the Specification. If adjustment of the mix design is agreed, the Contractor shall again be required to comply with Sub-clauses 2004 (3) and 2004 (4).

The Contractor shall take necessary action to remedy concrete which does not comply with this Specification. Such action may include but not necessarily confined to the following:

- Increasing the frequency of sampling until control is again established.
- Carrying out non destructive testing such as ultrasonic measurement, load tests or other appropriate methods.
- Cutting test cores from the concrete and testing in accordance with BS 1881
- Carrying out strengthening or other remedial work to the concrete where possible or appropriate.
- Removing the concrete.

2005. MIXING CONCRETE

Before any batching, mixing transporting, placing, compacting and finishing and curing the concrete ordered or delivered to site, the Contractor shall submit to the Engineer full details including Drawing of all the plant which he propose to use and the arrangements he propose to make.

Concrete for the works shall be batched and mixed in one or more plants or concrete mixer unless the Engineer agrees to some other arrangement. If concrete

mixers are used, there shall be sufficient number of mixtures including stand by mixers.

Batching and mixing plants shall be complying with the requirements of IS 1791 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixers shall comply with the requirements of IS 4925 and shall only be used with the prior approval of the Engineer. If the plant proposed by the Contractor does not fall within the scope of IS 1791 it shall have been tested in accordance with IS 4634 and shall have a mixing performance within the limits of IS 1791.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that the drainage water is not discharged to the weigh hoppers. Each bin shall be drawn at least once per week and any accumulations of mud or silt shall be removed.

If bulk cement is used, the scale and weight hopper for cement shall be distinct from the scale and weight hopper for aggregates.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in IS 1791 and not more than plus or minus one percent, and checked against accurate weights and volumes when required by the Engineer.

The weights of cement and each size of aggregate and the weight or volume of water as indicated by the mechanism employed shall be within a tolerance of plus or minus three per cent of the respective weight per batch agreed by the Engineer.

The Contractor shall provide standard test weights at least equivalent to the maximum working load used on the most heavily loaded scale and other auxiliary equipment required for checking the satisfactory operation of each scale or measuring device. Tests shall be made by the Contractor in the presence of the Engineer but not less than once per three months. The Contractor shall furnish the Engineer with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or the pan.

The blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

Mixers shall be fitted with an automatic recorder registering the number of batches discharged.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter at least once per hour and for each delivery of aggregates during concreting. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixers shall be cleaned out before changing to another type of cement.

2006. TRANSPORTATION OF CONCRETE

The concrete shall be discharged from the mixer and transported to the works by means which shall prevent adulteration, segregation or loss of ingredients, and shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall be within the tolerances specified in Sub-clause 2004 (5) (b) (i).

The capacity of the means of transport shall not be less than the full volume of a batch.

The time elapsing between mixing transporting placing and compacting altogether of a batch of concrete shall not be longer than the initial setting time of the concrete. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the works.

2007. PLACING OF CONCRETE

(1) Consent for Placing

Concrete shall not be placed until the Engineer's consent has been given in writing. The Contractor shall give the Engineer at least two full working day notice of his intention to place concrete.

If concrete placing is not commenced within 24 hours of the Engineer's consent the Contractor shall again request consent as specified above.

(2) Preparation of Surface to Receive Concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 900.

Existing concrete surfaces shall be prepared as set out in Clause 2012. Before deposition of further concrete they shall be clean, hard and sound and shall be wet but without any free standing water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump or be removed by other suitable which will prevent washing away the freshly deposited concrete or any of its constituents. Any under drain constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

Unless otherwise instructed by the Engineer surfaces against which concrete is to be placed shall receive prior coating of cement slurry or mortar mixed in the proportions similar to those of the fines proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be placed into all parts of the excavated surface and shall not be less than 5 mm thick.

If any fissures have been cleaned out they shall be filled with mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at one time shall be limited so that it does not dry out or set before being covered with concrete.

(3) Placing Procedures

The Concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items or form work. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 300 mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be thinner than four times the maximum nominal size of aggregate.

When placing on a nearly horizontal surface, placing shall start at the lower end of the surface to avoid decompaction of concrete.

Layers shall not be placed so that they form feather edges nor shall they be placed on a previous layer which has taken its initial set. In order to comply with this requirement, another layer may be started before initial set of the preceding layer.

All the concrete in a single bay or pour shall be placed as a continuos operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of

compacted concrete with no segregation or honey combing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items which protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be complied with.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In dry weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged from the place above its final deposition, segregation shall be prevented by the use of chutes, down pipes, trunking, baffles or other appropriate devices.

Forms for walls shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the Contractor shall submit to the Engineer his proposals for the method and equipment to be employed. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continuously full with concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the level of concrete in a tremie pipe is allowed to fall to such extent that the water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position. During and after concreting under water, pumping or dewatering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

(4) Interruptions to Placing

If the concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor

shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete in accordance with Clause 2008. All work on the concrete shall be completed before elapse of initial setting time and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all time during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remedy all damaged or uncompacted concrete, feather edges or any undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

In case of long interruption concrete shall be resumed as directed by Engineer.

(5) Dimension of Pours

Unless otherwise agreed by the Engineer, pours shall not be more than two meters high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the circumstances described in Sub-clause 2007 (4).

The Contractor shall plan the dimensions and sequence of pours in such a way that cracking of the concrete does not take place due to thermal or shrinkage stresses.

(6) Placing Sequence

The Contractor shall arrange that the intervals between successive lifts of concrete in one Section of the works are of equal duration. This duration shall not be less than three days or not more than seven days under temperate weather conditions unless otherwise agreed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete which is less than 21 days old.

Contraction gaps in concrete shall be of the widths and in the locations as shown on the Drawing and they shall not be filled until the full time interval shown on the Drawing has elapsed.

2008. COMPACTION OF CONCRETE

Concrete shall be fully compacted throughout the full extent of the placed layer. It shall thoroughly worked against the formwork and around any reinforcement and other embedded item, without displacing them. Care shall be taken at arrises or other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical of immersion vibrators, unless the Engineer agrees another method.

Immersion and surface vibrators shall operate at a frequency of between 70 and 200 hertz. The Contractor shall ensure that vibrators are operated at pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, stand-by vibrators shall be available for instant use at each place where concrete is being placed.

Vibration shall be continued at each until the concrete ceases to contract, air bubbles have ceased to appear, and a thin layer of mortar has appeared on the surface. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective and some extent of vibration is overlapped.

Vibration shall not be applied by way of reinforcement nor shall the vibrator be allowed to touch reinforcement, sheathing ducts or other embedded items.

2009. CURING OF CONCRETE

(1) General

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperatures differentials within the concrete sufficient to cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but not less than seven days or until the concrete is covered by successive construction whichever is the shorter period.

The above objectives shall be dealt with in Sub-clauses 2009 (2) and 2009 (3) but nothing shall prevent both objectives being achieved by a single method where circumstances permit.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process. In the case of large areas or continuous pours, it shall commence on the completed Section of the pour before the rest of the pour is finished.

(2) Loss of Moisture

Exposed concrete surfaces shall be closely covered with impermeable sheeting, properly secured to prevent its removal by wind and the development of air spaces beneath it. Joints in the sheeting shall be lapped by at least 300 mm.

If it is not possible to use impermeable sheeting, the Contractor shall keep the exposed surfaces continuously wet by means of water spray or by covering with a water absorbent material which shall be kept wet, unless this method conflicts with Sub-clause 2009 (3).

Water used for curing shall be of the same quality as that used for mixing.

Formed surfaces may be cured by retaining the formwork in place for the required curing period.

If instructed by the Engineer, the Contractor shall, in addition to the curing provisions set out above provide a suitable form of shading to prevent the direct rays of the sun reaching the concrete surfaces for at least the first four days of the curing period.

(3) Limitation of Temperature Differentials

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances including the following:

(a) limiting concrete temperatures at placing as set out in Sub-clause 2011 (2);

(b) use of low heat cement for mass concreting, subject to the agreement of the Engineer;

(c) leaving formwork in place during the curing period. Steel forms shall be suitably insulated on the outside;

(d) preventing rapid dissipation of heat from surfaces by shielding from wind.

2010. PROTECTION OF FRESH CONCRETE

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from these causes.

Concrete placed in the works shall not be subjected to any loading including traffic until it has attained at least its characteristic strength as defined in Clause 2004.

2011. CONCRETING IN HOT WEATHER

(1) General

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all plant and equipment required for this purpose.

In the event that conditions becomes such that even with the use of equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

(2) Concrete Placing in Hot Weather

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the works does not exceed 30^{o}C and that the concrete does not lose any moisture during transporting and placing.

Such measures may include but are not necessarily limited to the following:

(a) Shielding aggregates from direct sunshine.

(b) Use of a mist water spray on aggregates.

(c) Sun shields on mixing plants and transporting equipment.

Surfaces in which concrete is to be placed shall be shielded from direct sunshine and surfaces shall be thoroughly wetted to reduce absorption of water from the concrete placed on or against them.

After concrete has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

2012. CONSTRUCTION JOINTS

Whenever concrete is to be bonded to other concrete which has hardened, the surface of contact between the Sections shall be deemed a construction joint.

Where construction joints are shown in the Drawing, the Contractor shall form such joints in such positions. The locations of joints which the Contractor requires to make for the purpose of construction shall be subject to the approval of the Engineer. Construction joints shall be in vertical or horizontal planes except in sloping slabs where they shall be normal to the exposed surface or elsewhere where the Drawing require a different arrangement.

Construction joints shall be arranged as to reduce to a minimum the effects of shrinkage in the concrete after placing, and shall be placed in the most advantageous positions with regard to stresses in the structures and the desirability of staggering joints.

Feather edges of concrete at joints shall be avoided. Any feather edges which may have formed where reinforcing bars project through a joint shall be cut back until sound concrete has been reached.

The intersections of horizontal and near horizontal joints and exposed faces of concrete shall appear as straight lines produced by use of a guide strip fixed to the formwork at the top of the concrete lift, or by other means acceptable to the Engineer.

Construction joints formed as free surfaces shall not exceed a slope of 20 per cent from the horizontal.

The surface of the fresh concrete in horizontal or near horizontal joints shall be thoroughly cleaned and roughened by means of high pressure water, and air jets or wire brush, when the concrete is hard enough to withstand the treatment without the leaching of cement. The surface of vertical or near vertical joints shall be similarly treated if circumstances permit the removal of formwork at a suitable time.

Where concrete has become too hard for the above treatment to be successful, the surface whether formed or free shall be thoroughly scabbled by mechanical means, manually or wet sand blasted and then washed with clean water. The indentations produced by scabbling shall not be less than 10 mm deep and shall be away from the finished face by 40 mm.

If instructed by the Engineer the surface of the concrete shall be thoroughly brushed with a thin layer of mortar composed of one part of cement to two parts of sand by weight and complying with Sub-cluause 2502 (2) immediately prior to the deposition of fresh concrete. The mortar shall be kept just ahead of the fresh concrete being placed and the fresh layer of concrete shall be thoroughly and systematically vibrated to full depth to ensure complete bond with the adjacent layer.

No mortar or concrete shall be placed until the joint has been inspected and approved by the Engineer.

2013. RECORDS OF CONCRETE PLACING

Records of the details of every pour of concrete placed in the works shall be kept by the Contractor in a form agreed by the Engineer. These records shall include class of concrete, location of pour, date and duration of pour, ambient temperature and concrete temperature at time of placing and all relevant meteorological information such as rain, wind etc., moisture contents of the aggregates, details of mixes batch numbers, cement batch number, results of all tests undertaken, part of the structure and place where test cube samples are taken from.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceding week. In addition he shall supply to the Engineer monthly histograms of all 28 day cubes strength results together with cumulative and monthly standard deviations, Coefficient of Variation, and any other information which the Engineer may require concerning the concrete placed in the works.

2014. REINFORCEMENT

(1) General

Reinforcement as plain bars ad deformed bars and steel fabric shall comply with the following Indian Standards.

IS 1786 for high strength deformed steel bars and wires.

IS 1566 for steel mesh fabric.

IS 432 mild steel and medium tensile steel bars.

All reinforcement shall be from an approved manufacturer and, if required by the Engineer, the Contractor shall submit the ISI certification mark or other test certificate from the manufacturer acceptable to the Engineer.

The sampling and frequency of testing shall be as set out in the NS 84-2042 and NS 191-2045.

All reinforcement not complying with the Specification shall be removed from site.

(2) Storage of Reinforcement

All reinforcement shall be delivered to site either in straight lengths or cut and bent. No reinforcement shall be accepted in long lengths which have been transported bent over double.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall either be removed from site or may be tested for compliance with the appropriate Indian Standard in accordance with Sub-clause 2014 (1) at the Contractor expense.

Reinforcement shall be stored at least 150 mm above the ground on clean area free of mud and dirt and sorted out according to category, quality and diameter.

(3) Bending Reinforcement

Unless otherwise shown on the Drawing, bending and cutting shall comply with IS 2052.

The Contractor shall satisfy himself as to the accuracy of any bar bending schedules supplied and shall be responsible for cutting, bending, and fixing the reinforcement in accordance with the Drawing.

Bars shall be bent mechanically using appropriate bar benders. Bars shall be bent cold by the application of slow steady pressure. At temperature below $5^{o}C$ the rate of bending shall be reduced if necessary to prevent facture in the steel. Bending reinforcement inside the forms shall not be permitted except for mild steel bars of diameter less or equal to 12 mm, when it is absolutely necessary.

After bending, bars shall be securely tied together in boundless or groups and legibly labeled as set out in IS 2502.

(4) Fixing Reinforcement

Reinforcement shall be thoroughly cleaned. All dirt, scale, loose rust, oil and other contaminants shall be removed before placing it in position. If the reinforcement is contaminated with concrete form previous operation, it shall be cleaned before concreting in that Section.

Reinforcement shall be securely placed and fixed in position as shown in the drawing or directed by the Engineer.

Unless otherwise agreed by the Engineer, all intersecting bars shall be either tied together with not less than 1.6 mm diameter soft annealed iron wire and the end of the wire turned into the body of the concrete, or shall be secured with a wire clip of a type agreed by the Engineer.

Spacer blocks shall be used for ensuring that the correct cover is maintained on the reinforcement. Blocks shall be as small as practicable and of a shape agreed by the Engineer. They shall be made of mortar mixed in the

proportions of one part of cement to two parts of sand by weight. Wires cast into the block for tying in to the reinforcement shall have not less than 1.6 mm diameter and shall be soft annealed iron.

Alternatively another type of spacer block may be used subjected to the Engineer's approval.

All reinforcement shall be checked of shape, size, diameter and number where necessary. Reinforcement shall be rigidly fixed so that it remain intact during placing of concrete. Any fixers made to the formwork shall not remain within the space to be occupied by the concrete being placed.

No splices shall be made in the reinforcement except where shown on the Drawing or agreed by the Engineer. Splice lengths shall be as shown on the Drawing or directed by the Engineer.

Reinforcement shall not be welded except where required by the contract or agreed by the Engineer. If welding is employed, all welded splices shall be full penetration butt welds complying with the procedures set out in IS 2751 or IS 9417 as applicable. Mechanical splices shall not be used unless the Engineer agrees otherwise. Acceptance for welded or mechanical splices of approved design shall be based on qualification tests to be carried out by the Contractor prior to start of the work. Construction control testing as instructed by the Engineer shall be also carried out.

The Contractor shall ensure that reinforcement left exposed in the works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for mild steel bars of six times the bar diameter for high yield bars. Such bends shall be carefully straightened without leaving residual kinks or damaging the concrete round them before concrete placing. In no circumstances heating and bending of high yield bars shall be permitted.

Bars complying with IS 1786 or other high tensile bars shall not be bent after placing in the works.

2015. CONCRETE FOR SECONDARY PURPOSES

(1) Non-structural Concrete

Non-structural concrete (NS concrete) shall be used only for non structural purposes where shown on the Drawing.

NS concrete shall be compound of ordinary Portland cement and aggregate complying with this Specification.

The weight of cement mixed with 0.3 cubic metres of combined aggregate shall not be less than 50 kg. The mix shall be proportioned by weight or by volume. The maximum aggregate size shall be 40 mm nominal.

The concrete shall be mixed by machine or by hand in accordance with Sub-clause 2015 (3) to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted where required.

The concrete shall be compacted by hand towels or rammers or by mechanical vibration.

(2) No Fines Concrete

No fines concrete (NF concrete) is intended for use where a porous concrete is required and shall only be used where shown on the Drawing or instructed by the Engineer.

The mix shall consist of Ordinary Portland cement and aggregate complying with this Specification. The aggregate size shall be 40 mm to 10 mm only. The weight of cement mixed with 0.3 cubic metres of aggregate shall not be less than 50 kg. The quantity of water shall not exceed that required to produce a smooth cement paste which will coat evenly the whole of the aggregate.

(3) Hand Mixed Concrete

Concrete for structural purposes shall not be mixed by hand. Where non structural concrete is required, hand mixing may be carried out subject to approval of the Engineer.

For making hand mixed concrete, cement sand and aggregate shall be batched separately by volume or by weight as applicable. Then cement and sand shall be mixed dry to uniform colour. The aggregate shall be stacked in a proper shape upon which cement sand mix shall be spread and whole mix shall be turned up and down to have uniform mix of all ingredients. Then water shall be added as specified in Sub-clause 2015 (1) and shall be mixed to uniform consistency.

For hand mixed concrete the specified quantities of cement shall be increased by 10% and not more than 0.25 cubic meter shall be mixed at one time. During windy weather precautions shall be taken to prevent cement from being blown away in the process of gauging and mixing.

2016. EARLY LOADING

No load shall be applied to any part of a structure until the specified curing period has expired, and thereafter loading shall be allowed after approval by the Engineer. The Engineer's decision shall be based on the type of load to be applied, the age of concrete, the magnitude of stress induced and the propping of the structure.

No structure shall be opened to traffic until test cubes have attained the specified minimum 28 days strength as defined in Clause 2004.

2017. MEASUREMNT

(1) Concrete

Concrete laid in place as specified in the Drawing or directed by the Engineer shall be measured in cubic metre separately for each class. No deduction shall be made in the measurement for:

(a) bolt holes, pockets, box outs an cast in components provided that the volume of each is less than 0.15 cubic metres;

(b) mortar beds, fillets, drips, rebates, recesses, grooves, chamfers and the like of 100 mm total width or less;

(c) reinforcement

(2) Blinding Concrete/Non Structural Concrete

Blinding concrete laid in place shall be measured in cubic metre. No deduction shall be made for openings provided that the area of each is less than 0.5 square metres. Blinding concrete over hard material shall be measured as the volume used provided that the maximum thickness of 150 mm allowed for over break in not exceeded.

(3) Admixtures, Workability and Hardening Agents

Measurement of these items shall be carried out as specified in the contract.

(4) Reinforcement

All types of reinforcement shall be measured in metric tone in the ranges as given below:

- Diameter equal to or less than 8 mm
- Diameter above 8 mm upto 16 mm
- Diameter above 16 mm

Only that reinforcement which is required and placed in work as per Drawing or as directed by the Engineer shall be measured. Other reinforcement not shown on the Drawing or directed by the Engineer such as splices, chairs, cap lengths hangers and the like and the reinforcements not conforming to shape, size and length as shown on the Drawing or as directed by the Engineer shall not be measured.

Rolling margin or cutting waste shall not be measured. Length along centre line of the individual reinforcement of each type placed as described above shall be measured including their hooks, and bents, if any. An average weight of at least 5 samples each one metre length shall be determined by the laboratory approved by the Engineer. The weight of each type of the reinforcement shall be determined by multiplying average weight of the respective reinforcement by its length.

(5) Fabric Reinforcement

Fabric reinforcement laid as per Drawing or as directed by the Engineer shall be measured in square meter. No allowance shall be made for laps and wastage.

2018. PAYMENT

(1) Concrete

Every class of concrete shall be paid as per respective contract unit rate. In addition to those specified in Clause 112 the respective rate shall also include the cost of:

(a) admixtures and workability agents including submission of details unless specified.

(b) class of UF1, 2 or 3 surface finish.

(c) laying to sloping surfaces not exceeding 15o from the horizontal and to falls.

(d) formwork to lean concrete.

(e) placing and compacting against excavated surfaces where required including any additional concrete to fill over break and working space.

(f) complying with the requirements of Clauses 2001 to 2013, 1806 and 1807.

(2) Admixtures, Workability and Hardening Agent

Payment shall be made at contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 and for all specified in the contract.

(3) Reinforcement

The reinforcement shall be paid at contract unit rate. In addition to those specified in Clause 112 the rate shall also include compensation for the cost of providing, cutting to length, splice lengths additional to those shown on the Drawing, laps, bending, hooking, waste incurred by cutting, cleaning, spacer blocks, provision and fixing of chairs or other types of support, welding, fixing the reinforcement in position including the provision of wire or other material for supporting and tying the reinforcement in place, bending reinforcement aside temporarily, and straightening, place and compacting concrete around reinforcement and for complying with Clause 2014.

(4) Fabric Reinforcement

The fabric reinforcement shall be paid at contract unit rate which shall be also inclusive of compensation for wastage and laps.

(5) Payment for Sub-standard Works

Concrete not meeting the requirements of the relevant Specifications (termed as substandard concrete) shall be paid as substandard work provided it is accepted by the Engineer as substandard work. For the acceptance of such work the Engineer may require further investigation and/or tests which the Contractor shall conduct at his own cost. Acceptance or rejection of such work is the sole responsibility of the Engineer and his decision in this respect shall be the final and binding upon the Contractor.

If accepted as substandard work the payment for such work shall be made at the contract unit rate reduced by the formula given below

$$\text{Percent of reduction, } P = \frac{\text{Design strength} - \text{Observed strength}}{\text{Design strength}} \quad X\ 100$$

The reinforcement, admixtures, workability and hardening agents, if any, contained in the substandard concrete shall be also paid at their respective contract unit rate of the same concerned item reduced by the same percent P.

The reduced contract unit rates of substandard concrete and other items contained shall be the full and the final compensation to the Contractor.

SECTION 2100 – CONCRETE FOR STRUCTURES

SECTION 2100 – CONCRETE FOR STRUCTURES

2101. SCOPE

This section covers the materials, equipment and methods required for carrying out prestressing operations on in-situ concrete. This Section also covers the classes of concrete appropriate to prestressed concrete. The production of in-situ concrete is covered by Section 2000.

2102. GENERAL

Prestressed concrete work shall be carried out in accordance with IRC 18, 1985 and BSCP 110, 'The Structural Use of Concrete, Part 1, Materials and Workmanship', except that where the requirement of the Codes differ from this Specification, this Specification shall take precedence.

The Contractor shall submit to the Engineer full details of the plant he proposes to use for the installation of prestressing tendons, the materials he proposes to use and the arrangements he proposes to make. He shall also submit evidence of his competence to undertake the installation.

All prestressing components, sheathing ducts, anchorages, prestressing tendons, jack, etc. shall be stored in clean dry conditions. They shall be clean and free from rust at the time of fixing in position and subsequent concreting.

2103. CEMENT AND CONCRETE CLASSES FOR PRESTRESSED CONCRETE STRUCTURES

Cement for prestressed concrete shall be exclusively Ordinary Portland Cement (OPC) or High Strength Portland Cement (HSPC) complying with Clause 614.

Concrete classes for prestressed concrete shall be not less than M45/20 high quality concrete and shall comply with Section 2000.

2104. TENDON SHEATHS

Tendon sheaths shall conform the recommendation of IRC Code 18. Tendon sheaths shall be tested at the manufacture in accordance with Appendix 1 of IRC code and 18 and the Contractor shall provide test certificates in accordance with Clause 605.

All tendon sheaths or ducting shall be sufficiently strong to withstand without damage the stresses to which it may be subjected during handling and after being fixed in position. The ducting shall completely protect the wires or cables from contact with concrete and the Contractor shall ensure that the wires or cables are completely free in the duct before tensioning. Any ducting which has been

damaged during transportation to the site or which in the opinion of the Engineer is inadequate for its purpose shall not be used in the works. Ducting shall be free from loose material, oil coatings, or other contaminants which may affect the bond with the concrete.

The stools, saddles or supports for the ducts shall be of rigid construction and of such from that they remain securely in position and maintain the correct profile of the cables without strain on the sheath until the concrete placed round them has hardened. The supports shall be not more than one metre apart.

Vents shall be incorporated into each duct at high and low points, at each end and at intermediate points not more than five metres apart or in accordance with the Drawing. Blocking of vents during concreting operations shall be prevented.

2105. ANCHORAGES

Anchorages shall be the correct type for the prestressing system and must have been used in similar other works. The procured anchorages shall conform to BS 4447. They shall be rigidly fixed true to alignment in the formwork so that they cannot move during concreting operations. The anchorages shall be provided with means for rejecting grout into the ducts.

Anchorages shall be delivered on site in protecting packing against corrosion with adequate information of identifying the articles and with the manufacturer's detailed instructions for their use.

If the anchorage is fixed after the main body of the concrete has been placed, it shall be carefully bedded so that it is bearing evenly and is in intimate contact with the concrete.

2106. PRESTRESSING TENDONS

Tendons and wires used in prestressed concrete shall comply with the standards indicated on the Drawing. The Standards include the following:

IS 1785 Part 1	for Plain hard - drawn steel wire
ASTM A 416	for high tensile strength strand.

All wires, bars and/or strands shall be assigned the lot number and shall have suitable tags for their identification. All samples shall be truly representative of the lot to be furnished and in the case of wire or strand. The Contractor shall furnish samples of at least 5 m length selected form each lot for testing.

Tendons shall be stored on site under cover and protected from the weather. The storage area shall have a hard impermeable floor. Tendons shall be stored either straight or in the coils in which they left the factory.

Tendons shall not be allowed to become affected by excessive rusting or by pitting of the surface by corrosion. If pitting is present the Contractor shall replace the affected tendons by new ones. Tendons shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil.

2107. INSTALLATION OF PRESTRESSING TENDONS

(1) Fabrication Procedures

Fabrication shall be carried out clear of the ground and under cover, or where this is impractical, and agreed by the Engineer, in the open with suitable precautions.

The fabrication procedures shall not cause any mechanical damage to the tendons. Any tendon material found to be bent or kinked at fabrication shall be rejected unless tests are made to the satisfaction of the Engineer which show that the damage is not detrimental.

Prestressing steel shall be cut by rotating disc or blade cutters or by such method as is recommended by the manufacturer.

Where required for the particular system, the ends of the tendon shall be prepared at fabrication for subsequent stressing and anchoring.

(2) Installation and Fixing

Before being installed, prestressing tendons shall be thoroughly cleaned of mill scale, mortar, oil, paint, dust, grease, or any other deleterious matter whatsoever.

The prestressing steel (or where the tendons are accommodated in ducts, the sheaths, ducting or formers) shall be accurately placed in the position shown on the Drawing and shall be firmly secured in position. They shall not deviate from the positions shown on the Drawing by more than 5 mm in all directions.

Wooden supports shall not be used nor shall the sheaths, ducting or formers be placed on previous layers of fresh concrete or be adjusted during the placing of concrete.

The prestressing steel, sheaths, ducting or former shall be so placed and secured that twisting, kinking or excessive deformation during and subsequent to concreting is eliminated and the prestressing tendons when finally stressed shall conform accurately to the profiles shown on the Drawing. Ducts and formers shall not be placed with small radius bends which would induce excessive frictional restraint on the wires or strands.

Where many individual wires or strands are placed in a duct, adequate provision shall be made to keep the wires separated by means of suitable spacers of approved design, construction and spacing.

2108. JACKS FOR PRESTRESSING

Jacks for tensioning tendons shall be hydraulically operated and capable of providing a slow uniform increase of load.

Each jack shall be equipped with an appropriate pressure gauge capable of indicating the hydraulic fluid pressure at all times during the stressing operation with an accuracy of 1 N/mm^2. A certified calibration chart showing the relationship between gauge readings and force on the ram for both ascending and descending ram movements shall be made available on the site by the Contractor.

The Contractor shall maintain tensioning jacks in good working order and shall ensure true and accurate readings by regular testing, calibration and servicing.

2109. TENSIONING OPERATIONS

(1) General

Prestressing force, whether partial or full, shall not be transferred to the concrete until cube crushing tests have indicated that the concrete has attained the strength specified on the Drawing. The test cubes shall have been cured in conditions similar to the concrete to be prestressed.

Stressing of the tendons shall be carried out with due care by experienced workmen under competent supervision approved by the Engineer. Adequate steps shall be taken to safeguard against injury. Special precautions shall be taken when working with and near tendons which have been tensioned or are in the process being tensioned.

The Contractor shall ensure that he has been supplied all required instructions by the Engineer and that he has the necessary information to carry out the works. The instructions controlling the stressing operations are based on the design of the structure and may be modified by the Engineer as a result of the information obtained from site tensioning records.

Full and accurate records shall be kept of all stressing operations and two copies of the records, which shall include welding-device slip measurements during anchoring, loads and extensions, shall be submitted to the Engineer on the day following each stressing operation. The accuracy of the measurement of cable extensions, shall be plus or minus two per cent (± 2). The Engineer may order the Contractor to cease any or all stressing operations where proper records are not being kept or where the operations are not being properly or safely carried out. The Contractor shall take

immediate steps to ensure that the work is carried out to the satisfaction of the Engineer.

Where the required tensions or extensions are not obtained the tendons shall be re-tensioned as directed by the Engineer. If on re-stressing, the extensions are not achieved, the Engineer may at his discretion reject the tendons involved.

The tendons shall be maintained in such condition that they can be restressed until the Engineer has given final approval after inspecting the tensioning log.

(2) Post-tensioning

When a post-tensioning system is employed, all cable ducts, excluding extractable formers shall be thoroughly flushed with water immediately after concreting and before the concrete has hardened.

Ducts produced by extractable formers shall be flushed out as soon as the concrete has hardened. Where anchorage of the prestressing tendons is by friction grips or wedges and where no other shipping limitation in specified, the slip of each individual prestressing steel element, both during tensioning and after anchoring shall not exceed seven millimeters. Tendons failing to satisfy this limitations shall be re-stressed.

The sequence of stressing shall be as shown on the Drawing and shall be such that lateral eccentricity of stress on any member is reduced to a minimum.

After stressing and anchoring, no tendon shall be cut, bent or in any way deformed until the Engineer has given his final approval.

Where tendons are cut back, the exposed ends of the tendons and anchorages shall be heavily coated with an approved bituminous compound or epoxy resin to prevent corrosion of the prestressing steel.

2110. BONDING AND GROUTING

After stressing and anchoring post-tensioned tendons shall be intimately bonded to the adjacent concrete by means of concrete or in the case of internal cables, by colloidal cement grout.

The properties of grout, the equipment and the grouting procedure shall be as follows:

(1) Grout Type

The grout shall be a colloidal mix of water and ordinary Portland Cement with a water/Cement ratio of between 0.40 and 0.45 by weight.

A admixtures of an approved type may be authorized by the Engineer for incorporation in the grout if tests have shown that their use improves the properties of the grout, for examples by increasing the workability, by reducing bleeding, or expanding grout.

Admixtures shall not contain chlorides or nitrates. When an expanding agent is used the total unrestrained expansion shall not exceed 10 per cent.

(2) Mixing Equipment and Procedures

The mixing equipment shall be of a type capable of producing grout of uniform consistency with fully dispersed cement particles and shall be incorporated with suitable sieves for retaining lumps or other solid ingredients. After water has been added to the mixer, the cement shall be added. Admixtures if used, shall be added during the latter half of the mixing time. High speed mixing shall be carried out continuously for between two and four minutes in a close clearance high speed centrifugal mixer.

Subsequent to mixing and prior to injection the grout shall be continuously agitated by slow machine mixing. Any grout has been left standing for more than 30 minutes shall be discarded and the container thoroughly washed before further mixing is carried out.

(3) Injection Equipment and Procedures

A positive displacement pump shall be used for injecting the grout, capable of developing a pressure of at least 1 N/mm^2. The pump shall be fitted with a pressure gauge and an effective control against build-up of excessive pressure. The pump suction intake shall be kept below the surface level of the grout at all times during grouting operations.

All tendons shall be grouted in their ducts as soon as practicable after the stressing operation. Each duct shall be cleaned by blowing through compressed air, flushing with clean water and surplus water shall be removed by compressed air or other approved means. Openings at the anchorages other than grout injection nozzle openings shall be plugged with mortar or other suitable material. Subsequent to the hardening of the plugging material the nozzle of the injection pipe shall be firmly connected to the duct in such a way that air cannot be sucked in. Injection shall be commenced from one end only and its progress monitored by the appearance of grout at successive vent holes. When the consistency of the grout emerging from a vent is equal to that of the grout being injected, that vent shall be plugged.

Injection shall continue until grout of a consistency equal to that injected appears at the far end of the duct. The injection nozzle shall then be withdrawn and all holes and vents plugged to prevent loss of grout.

As far as possible all ducts in any one member shall be grouted in immediate succession commencing with the lowest duct.

Grouting shall not be carried out when the air temperature is 2^{o} C or lower

The temperature of newly grouted cable ducts shall be prevented from falling below 2^{o} C for a minimum period of seven days.

(4) Quality Control

The grout shall be tested in accordance with the Standards and Codes and its fluidity, bleeding, setting and compressive strength shall comply with the following requirements:

- Fluidity measured with a 10 mm funnel output Marsh cone shall be less than 25 seconds.

- Bleeding shall be less than 2% by volume hours after mixing, with a final maximum value of 4%. Separated water shall be re-absorbed within 24 hours.

- The compressive strength of the hardened grout shall not be less than 17 N/mm^2 at seven days.

To demonstrate that the grout type and equipment are meeting the requirements of this Specification, the Contractor shall carry out a site trial in accordance with Section 500 at least 25 hours before the intended date to commence the work.

2111. REJECTION OF PRESTRESSED WORK

Any prestressing tendons, anchorages, or any part whatsoever of prestressing component which has been damaged during the tensioning operation shall be rejected.

In cases where excessive loss of prestress has occurred or in which grouting has not been satisfactorily carried out, or which is deficient in any other manner, the Contractor shall propose corrective measures to the Engineer's agreement. The Contractor shall not rectify any deficiency prior to the Engineer's agreement or instructions. Corrective measures shall be carried out to the satisfaction of the Engineer and at the Contractor's expenses failing which the element shall be replaced by the Contractor at his cost.

2112. TESTING PRESTRESSED WORK

If instructed by the Engineer, load testing of structures containing prestressed units shall be carried out generally as set out in BSCP 110.

Details of all testing procedures shall be agreed between the Engineer and the Contractor before testing is commenced.

2113. MEASUREMNT

Prestressed concrete shall be measured in cubic metre.

Tendons for prestressing shall be measured in tonne computed on the basis of their total length and weight per unit length.

Provision of ducts/sheaths shall be measured in number which shall be inclusive of removal of extractable formers and then grouting in ducts.

Anchorage assembly shall be measured in number fixed placed with all accessories.

Formwork, staging scaffolding shall be measured and paid as per Section 1800.

2114. PAYMENT

Prestressed concrete, tendons, duct/sheaths anchorage assembly shall be paid as per their respective contract unit rates which be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of load tests if specified, and other ancillary and incidental works necessary to complete the item as per this Specification.

SECTION 2200 – STRUCTURAL STEELWORK

SECTION 2200 –STRUCTURAL STEEL WORK

2201. GENERAL

(1) Scope

This Section covers fabrication, storage, handling and erection of steel structures excluding those covered by Sections 1600 and 1900.

(2) Codes of Practice

The fabrication, storage, handling and erection of structural steel works shall comply with the relevant Sections of the IS and IRC, if otherwise not specified in the contract.

Should there be any disagreement between IS and IRC, the provision in the IRC shall prevail to the extent of the disagreement.

2202. MATERIALS

(1) Material for use in connection with the protection of the steel work against corrosion are specified in Clause 2209. Other materials used in connection with steel structures such as concrete, bearing pads, etc., shall be governed by the appropriate Sections of these Specifications. Unless otherwise specified or described in the contract, structural steel materials shall comply with the appropriate standards listed below.

IRC 24-1967	:	Standard Specifications and Code of Practice for Road Bridges.
IS 2062-1992	:	Steel for General Structural Purposes.
IS 9550-1980	:	Specifications for Bright bars.
IS 3757-1985	:	Specifications for High Strength Structural Bolts.
IS 6623-1985	:	Specifications for High Strength structural Nuts
IS 6649-1985	:	Specifications for Hardened and tempered Washers for High Strength Structural Bolts and Nuts.

2203. FABRICATION: GENERAL REQUIREMQNTS

(1) General

This Clause shall apply to all operations undertaken in the fabrication in the workshop or elsewhere whether on or off the site. The requirements contained herein shall not be waived, nor shall be modified to conform to any set of rules that any shop adopted as its standard unless so authorized in writing by the Engineer.

Substitution of structural Section of different dimensions, weight or strength from those specified in the contract may be made only when approved in writing by the Engineer. No payment shall be made for increased weight or strength/properties resulting from approved substitution, but any decrease in weight shall be deducted from the final pay quantity.

The various components/elements of the steel structure shall be fabricated in accordance with the approved shop Drawing. Any errors or omissions in them shall be reported to the Engineer, and his decision for their correction shall be final.

(2) Shop Details Drawing

The Contractor shall furnish shop detail Drawing for the complete fabrication of all components/elements required by the contract. When it is specified in the contract that the employer shall furnish prints of standard shop detail Drawing, the Contractor shall be required to make any additions or revisions to the detail Drawing as may be necessary to produce a finished structure in accordance with the contract. Shop detail Drawing shall consist of detailed Drawing showing the dimension and sizes of the components/elements, bolt lists for field erection, a match marking diagram, complete field erection Drawing and such other details and information as may be necessary for fabrication.

Shop detail Drawing of widening or reconstruction work shall contain sufficient field dimension, so that the shop Drawing may be checked. The Drawing shall also contain a note to the effect that these are field measurements which the Contractor has furnished and for which he is responsible. Such detail drawing shall also show a portion of the existing work, using light dotted lines or coloured ink for this purpose.

Shop detail Drawing shall be prepared in a neat and legible form, on the dull side of tracing cloth, with India ink, or by other methods approved by the Engineer. Each sheet shall have a title in the lower right hand corner giving the fabricator’s name, the fabricator’s contract number and brief description of the details shown on the sheet.

Bills of material and bolt lists may be furnished on the fabricator’s own standard sheets.

The Contractor shall submit blueprints of shop Drawing to the Engineer for approval. No work shall be done in the shop until such Drawing has been finally approved. In general, 2 sets of preliminary prints shall be required, but the Contractor shall furnish additional prints free of charge upon request. Only checked Drawing in complete sets shall be submitted for approval. The details of anchorages, bearing plates, castings, etc., shall be submitted in advance, in order to avoid delay in construction.

When changes on the submitted Drawing are requested by the Engineer, or when the Contractor makes additional changes, other than those requested, attention shall be called to the changes on the blueprints submitted for approval by encircling or underscoring all change with contrasting coloured ink or rayon.

After the Drawing has been finally approved, the Contractor shall, without direct compensation thereof, furnish to the Engineer 4 sets of prints of the corrected Drawing, and such additional prints as may be required. The shop Drawing as approved by the Engineer shall become a part of the contract.

The ordering of material or the performance of shop work prior to the Engineer's approval of shop Drawing shall be at the Contractor's risk and cost. No changes shall be made in any approved Drawing without the written authorization of the Engineer. The Engineer's approval of shop Drawing shall not relieve the Contractor of responsibility for the accurate assembly and fitting of all structural members. After the shop work has been completed, the Contractor shall deliver to the Engineer all of the original tracings of the shop details, or positives thereof, on cloth.

(3) General Shop Practice

(a) Storage

Before and after fabrication, all materials shall be so stored that they are not deformed or damaged, and shall be protected against the accumulation of water, dirt, oil or other foreign matter. Material that has become pitted from exposure or other causes shall not be acceptable for any use. Material that has been damaged during storage shall be replaced with equivalent or better material.

(b) Identification

Structural alloy steel shapes and Sections shall, in addition to standard mill practice identification, be further identified during all operations, from the mill to the completely fabricated structure, by the use of, and continued maintenance of, colour coding in accordance with IS 2049.

Alloy steel and non-ferrous alloy bolts shall be identified by coded markings embossed or impressed on the head or tip during

manufacture. Pieces on which identification has been lost shall be rejected.

(c) Workmanship and finish

All metals shall be neatly and accurately cut to required size with proper allowance as may be necessary or required for finishing operations.

All fins, ragged or distorted edges resulting from shearing, speed sawing, or frame cutting shall be removed by milling, chipping, or grinding.

Shearing shall not be used for the purpose of cutting non-ferrous metals where the thickness is greater than 13 mm.

(d) Flame cutting

The gas cutting torch may be employed in the operation of cutting metals or preparing joints provided that the metal in not carrying stress during the operation. Carbon steel above 0.30 carbon alloy steel, heat treated steel or aluminium, wrought non-ferrous metals and plated metal shall not be flame cut unless subsequent corrective treatment is provided which shall be subject to the approval of the Engineer.

When the cutting torch is used, the burned edges shall be trimmed smooth to exact lines by milling, chipping or grinding. Maximum deviation for "free hand" cutting shall be 1.5 mm from true lines. A mechanical guide shall be used for the flame cutting torch on all work requiring precision cutting on which the maximum deviation permitted shall not be greater than 0.8 mm. All "notch effects" shall be completely removed form the portions of members where the extreme fibre is subject to flexure, tension or perpendicular shear.

Where the ends of members which are to which are to take bearing, are cut with a torch, a suitable allowance in their length shall be made to permit proper milling or planning.

Joints for welding may be prepared by "flame gouging" provided all slag and oxidized metal are removed.

(e) Re-entrants

Interior and re-entrant corners shall be filleted to a 25 mm radius unless a shorter radius is indicated in the plan. Fillets less than 25 mm in radius shall be formed by drilling.

(f) Bending

All bending or crimping shall be done at the bend lines shown, by a mechanical operated press, without unnecessary loss of Section in the metal being bent. The bends shall conform to wood or metal templates. All low carbon steel and other wrought metals shall be bent cold when the required bending will not produce cracks or fractures. When heating is necessary to accomplish bending of ferrous metals, the material shall be carefully heated to and bent at or above a temperature by a dark red colour, but in no case at a lower temperature. All material bent below such temperature shall be rejected and annealing shall not be considered a corrective measure. Heated material shall be slowly cooled after the bending operation. Heat treated metals shall be shaped before heat treatment. Material having fractures or other defects caused by bending shall be rejected.

Cold-bent load-carrying rolled steel plates shall conform the following:

(i) They shall be so taken from the stock plates that the bent-line is at right angles to the direction of rolling.

(ii) The radius of bends, measured to the concave face of the metal shall be more than specified below.

Angle through which plate is bent	Radius
61^o to 90^o	1.0 T
91^o to 120^o	1.5 T
121^o to 150^o	2.0 T

Where T is the thickness of the plate undergoing bend.

(iii) Before bending, the corners of the plate shall be rounded to a radius of 1.5 mm throughout that portion of the plate at which the bending is to occur. If a shorter radius is essential, the plates shall be bent hot.

(g) Straightening Material

All wrought and extruded Sections must be made straight or cambered as shown in the plane before being marked, punched or otherwise worked on in the shop. If straightening is necessary, it shall be done by method which will not change the physical properties, reduce the Section, or otherwise damage the metal. Material which develops kinks, fractures or evidence of embitterment shall be rejected. Materials that are warped by cutting, punching or welding shall be straightened to correct lines and dimensions before being assembled. Sections that are distorted during assembly and/or welding shall be

straightened by methods that will not shear, fracture, or pre-stress the welds or connecting members. If, in the opinion of the Engineer, Section can not be properly straightened after assembly, the bent material shall be taken out, straightened and reassembled in the unit. Any material damaged during such operations shall be replaced with equivalent or better material.

Unless otherwise specified in the contract, structural steel Section which deformations do not exceed normal rolling tolerance will be acceptable without straightening. When the plans so indicate, beams shall have unwrapped webs with flanges at true right angles thereto. Such beams shall, if necessary, be straightened cold by an approved method of web pressing.

(h) Layouts and Templates

Full scale layouts will be required for intricate portions of structures that present problems or fabrication or erection. When requested by the Engineer, such layouts shall be made available to him for checking purposes. Duplicate work shall be fabricated with the aid of templates or jigs. Wood or metal templates shall be used for all mitre joints except when an approved jig is used. Reaming or drilling temperatures shall be made of metal, using hardened steel bushing 25 mm thick.

Sweeps for laying out and checking curved surfaces shall be made of wood or metal and shall be of sufficient length to produce accurate results.

Working points and working lines shall be clearly marked on all templates and sweeps.

All templates shall be made available for the Engineer's use.

(i) Built-up Members

A built-up member shall be true to detailed dimensions and it shall be free of twists bends, open joints, or other defects resulting from faulty fabrication or workmanship. The assembly shall be such that all field joints will have the planned clearance. The joints shall be smooth, and free from all burrs or other obstructions.

Closed Sections or pockets which might harbour moisture or dust and which cannot be readily cleaned and painted shall be filled with plates or closed by caulking or welding. Filler plates shall be full size and fitted sufficiently tight to exclude all moisture and dust after being painted. Tack welding may be employed to hold fillers in place.

(j) Incidental Items

The following items shall be furnish by the Contractor without additional payment unless otherwise provided for in the contract.

(i) Pilot Points and Driving Nuts:

One new pilot and one driving nut for each size of shouldered pin.

(ii) Erection Pins, Bolts and Washers:

All erection pins, bolts and washers necessary for field erection

(iii) Field Rivets:

Extra rivets of each size and length, in the amount of 10 rivets plus 10 per cent of number actually required for field erection, to compensate for loose due to misuse, improper driving or other contingencies.

(iv) Field Shims:

Shims 3 mm or more in thickness shall be made of structural steel and those thinner than 3 mm shall be made of sheet brass.

"Field shims" shall be constructed to mean all metal plates which are required, because of inequalities or inaccuracies in fabrication or erection or because of the substitution of Sections by the fabricator, to bring metal surfaces of members into contact or to bring the structure to the required grade and alignment. "fillers" shall be constructed to mean metal plates which are required by the design to bring metal surfaces of members into contact or to bring the structure to the required grade and alignment, and shall be included in the quantities for which payment shall be made.

(v) Sections:

Increase of Sections over net size required in the contract, and other Sections, metals, parts, or equipment added for the purpose of erection only which may or may not subsequently remain a part of the finished structure.

(4) Machining

(a) Definition of Terms

(i) Rough Finish:

The surface shall be true but may show very slight grooves.

(ii) Finish:

The surface shall be true and smooth and shall show no visual evidence of grooves.

(iii) Smooth Finish:

The surface shall be true ad perfectly smooth to the touch.

(iv) Polished Finish:

The surface shall be true, smooth and polished.

(v) Milled Finish:

The surface shall be the same as the defined for rough finish,

(vi) Bored Finish

The surface shall be the same as that defined for smooth finish.

(b) Machine Lubricant

Soap water solution shall be used as a lubricant on all structural material requiring machine work. The use of oil or grease shall not be permitted for this purpose. Cutting oil shall be used on machinery parts and bolt stock.

(c) Edge Planning

Structural steel plates with sheared edges having a thickness of more than 16 mm and structural alloy plates having a thickness of 13 mm or more, except web plates for built-up girders, sole or base plates, and fillers, shall be planed to correct size with square edges by removing not less than 6 mm of metal. The use of mechanically guided needle torch may be permitted in lieu of specified edge planning of expansion plates when used for the purpose of making bevel cuts.

(d) Bearing Surfaces

After a column has been otherwise completely welded and before the cap or base plates are attached, the bearing surfaces shall be milled to the angle shown in the plan.

End connection angles shall be welded to the main member before milling.

Cap and base plates of columns shall have full contact with the surface after assembly. Sole plates of beams and girders shall have full

contact with the flanges. Warped for deformed plates shall be machine finished or otherwise straightened by an approved to secure an accurate and uniform contact. Countersunk river heads or extruding weld metal shall be chipped smooth and flush with the surrounding surface.

Castings shall be machined as indicated in the plan.

Bronze bearing plates shall have a "Polished Finish"

(e) Abutting Joints

The ends of members shall not be milled until such members have been completely welded. Members whose ends are improperly milled shall be rejected.

The ends of members forming a compression joint or splice shall be accurately milled to proper length, alignment and bearing, using a wood or steel template as a guide. Gusset plates connecting milled ends of members shall conform to the same wood or metal templates from which the milled ends were formed. The use of bevel square shall not be permitted.

Joints in main chord tension members shall be close and neat, and in no case shall the opening be more than 3 mm.

(f) Boring Pin Holes

Pin holes shall be accurately located as detailed, and bored true to exact dimensions. They shall be bored smooth, straight, and at right angles to the axis of member. A finishing cut, which shall be a complete and separate operation, will be required.

Unless otherwise indicated in the plans, the difference in diameters of the pins and the pin holes shall be 0.8 mm exact.

(g) Pins and Rollers

Pins and rollers shall be accurately turned to the detailed dimensions. The final surface shall be smooth, straight, and free from flaws. The final surface shall be machined to a smooth finish.

All bridge pins and roller 150 mm in diameter and smaller shall be made of Bright steel bars complying with IS 9550.

All segmental rollers and all pins whose nominal diameter is to be greater than 150 mm shall be made from annealed forging.

A hole 50 mm in diameter shall be bored longitudinally through the centre of each pin or roller having a diameter greater than 230 mm. Pins or rollers showing defective interiors shall be rejected.

Pins shall be held in place by recessed nuts. The nuts shall be hexagonal in sharp and shall be made of malleable iron, pressed or cast steel. The grip face of the nuts shall be machined square to the axis of the pin. Pins and nuts shall be accurately made so that the recessed face of the nut will bear uniformly against the end face of the pin when the nut is turned up tight. The threaded portion of the pin shall project at least 6 mm through the nut after assembly. Where a recessed cut is made between the threads and the shoulder of the pin, it shall not be wider than 6 mm nor deeper than the base of the thread.

(5) Marking and Dispatching

All material shall be accurately and legibly marked according to the field erection plan, prior to dispatch. Such markings shall be made with contrasting paint on previously painted surfaces. The omission of marks on duplicate pieces shall not be permitted unless otherwise authorized by the Engineer.

When practicable, loose connection plates for a member shall be bottled in position thereon for shipment. All rivets, bolts, nuts and washers shall be parceled separately as to size. They shall be shipped in suitable containers, but the gross weight of any single container shall not exceed 100 kg. A list and description of the included material shall be plainly marked on the outside of each container.

Pins, roller nets, name plates, sheet lead, and small parts be boxed or crated for shipment. Pins shall be shipped with the nuts in place.

When the Engineer directs, finished work shall be weighed in the presence of the Inspector. The fabricator shall supply satisfactory scales and shall do the handling and weighing. When requested by the Engineer, members weighing more than 300 kg shall be marked to show their scale weight.

The loading, unloading, handling, transportation and storing of structural material shall be carefully conducted so that the metal will be kept clean and free from damage. All girders, partly assembled trusses, and large I beams shall be transported in an upright position. Cambered members shall be securely blocked to prevent any loss of camber. All sheets land copper waterstops shall be crated for transport.

Anchor bolts, pier nose angles, and other anchorage or grillage materials shall be dispatched in advance of other material to suit the requirements of the construction work.

(6) Shop Painting

All ferrous metals which have not been plated, galvanized or enameled shall be given one shop coat of paint of the kind specified in the contract. Non-ferrous metals shall not be painted or otherwise surface treated unless so specified in the contract. All cleaning and painting shall conform to Clause 2209.

(7) Inspection and Testing

(a) General Requirements

The Contractor shall advise the Engineer as to the actual date and place of preparation of materials so that sufficient time may be had, prior to such preparation, to arrange for inspection. This inspection will be dependent upon the character and importance of the work and may involve inspection in the mill, the foundry, the fabricating shop and the field, as may be considered necessary by the Engineer. Information relative to the time of beginning various operations, such as mill rolling, foundry casting, heat treating, shop layout, punching, riveting, welding, milling, assembling, painting and shipping, shall be furnished to the Engineer in sufficient time so that he may provide for the proper supervision and inspection of the work. In general 28 days shall be considered as the required time of advance notice. Failure to furnish information shall result in the rejection of the material involved.

The Employer may depute structural-metals-inspectors for the inspection of all metals at the plant or in the field. When such inspection service can be furnished in the usual routine manner without any additional expenditures, no charge shall be made against the Contractor. When such inspection service entails additional costs, the Contractor shall be charged for the expense incurred but such charges shall not be greater than the amount specified in the contract per person per ton, based on the total metal tonnage of the contract.

As soon as the progress of the work permits, the Contractor shall furnish to the Engineer 2 copies, or more, if required, of each of the following:

> Mill or purchase orders, certified reports of physical characteristics and chemical analysis of all materials involved, and the fabricator's shipping statements showing the net scale weight of each shipment. When requested, the scale weights of individual member or Sections shall be furnished.

All materials and workmanship shall be subjected to inspection and Engineer's agreement. The inspection of materials and fabrication shall as far as possible be carried out at the place of manufacture.

Expect as provided for above no fabricated steelwork shall be dispatched to the Site before it has been inspected and agreed. All inspected and agreed steelwork shall be marked in accordance with the agreed procedures.

(b) Inspector's Authority

The Inspector shall reject the materials and/or the workmanship which do not fulfill the requirements of the contract. However, in cases of dispute, the Contractor may appeal to the Engineer, whose decision shall be the final.

Inspection at the mill and shop is provided for the purpose of facilitating fabrication work and to avoid errors, but such inspection shall not relieve the Contractor of his responsibility for the correction of errors and faulty workmanship or for the replacement of imperfect materials.

(c) Facilities for Inspection

The Contractor shall furnish all facilities, tools and such assistance as the Inspector may require for the inspection of material and workmanship in the mill, foundry or shop. The inspector shall be granted free access to the plant premises for the required inspection service. All fabricated parts shall be piled separately in such a manner as to facilitate inspection.

The Contractor shall furnish office space at the fabrication plant for the Inspector's use during the period of fabrication, assembly and paintings.

(d) Testing

Unless otherwise provided, the Contractor shall furnish test specimens as specified, and all labour, testing machines and tools necessary to prepare the specimens and to make the prescribed tests. Where check tests are required by the Engineer to determine the suitability of any materials, the Contractor shall furnish representative samples for further testing by the Engineer before such material is finally approved for use.

Where no specified tests are provided for in the contract, tests for metals shall be conducted in accordance with the Engineer's directions.

(e) Rejection

Rejected materials and workmanship shall be promptly replaced with satisfactory material and workmanship. Any shipment of materials

that has been damaged in transit shall not be unloaded until an agreement as to its disposition has been reached with the Engineer.

2204. FABRICATION OF BOLTED STRUCTURES

(1) End Connection Angles

End connection angles of floor beams, stringers and diaphragms shall be accurately assembled to the dimensions shown in the plan, and the length, back of angles, shall be exact. Unless otherwise specified, the finishing of end connection angles shall not be required except as a correction to a faulty assembly. When finishing is necessary for such correction, the thickness of the angles shall not be reduced by more than 3 mm but in no case shall the final thickness of the angel be less than 9 mm. Portions of members extending beyond the face of the connection angles shall be chipped or ground flush. No portion of a web or a connecting member shall be recessed more than 9 mm from the face of the connection angles.

(2) Stringers

Stringers shall be straight and their bearing surfaces shall be true, and free from all burrs and distorted edges.

The fixed ends of stringers supported on brackets or on the top flanges of floor beams shall be secured by means of bolts having hexagonal heads and nuts.

The maximum clearance between abutting ends of stringers shall be 13 mm unless otherwise specified. Stringers supported on brackets shall have a maximum clearance of 13 mm between the end of the stringer and the web of the floor beam.

(3) Expansion Devices

Expansion and deflection devices shall be exact dimensions, and no tolerance in materials or dimensions shall be allowed. Unless otherwise indicated in the plan these devices shall be secured to stringers or floor beam by means of bolts having hexagonal heads, hexagonal nuts and lock washers.

(4) Bolted Plate Girders

The web plate of a finished girder shall in no case project beyond the face of the flange angles or end stiffener angles. In girders with full-length cover plates, the edges of the web shall not be more than 6 mm inside the face of the flange angles except that, in cases of cambered beams, the width of the web may be 13 mm less than the distance (back to back) between the flange angles provided the web is centred. In girders without cover plates, the edges of the web shall not be more than 3 mm below the face of the top flange angles. In girders with partial length cover plates, the above

requirements shall apply together with the additional requirement that, unless the edges of the webs are flush with the faces of the flange angles at the ends of the cover plate, any space between them shall be plugged with a weld at least 13 mm long. In no case shall the ends of the webs be more than 9 mm inside the face of the end stiffener angles.

Holes in all girder web splices shall be subpunched or subdrilled. After assembly these holes shall be reamed to specified size.

Splicing of flange angles shall not be permitted, unless required by the Contract, except when girders are to be constructed with curved ends, in which case the flange angles shall be spliced near the curved portion to facilitate bending and assembly. Curved and flange angles shall be bent in pairs. After bending, the curved angles shall be true to the plan radius and free of all wrinkles or waves. After assembly, these curved end angles shall be butt welded to the flange angles, and the weld shall then be ground smooth.

When splices in flange angles are required by the contact, the abutting ends of the angles shall be milled to a close fit. All holes in such splices shall be subpunched and reamed, or drilled form the solid. Smoothly ground butt welds will be acceptable for joints in flange angles in lieu of milling. Such welds shall not be considered as a substitute for the splice plates or angles as detailed.

Unless otherwise indicated in the plan, end stiffeners and intermediate stiffeners intended for supports for connectrated loads shall be milled or ground smooth to secure a uniform, even bearing against the top and bottom flange angles. When welding is indicated or permitted in lieu of milling or grinding, the welds shall be of sufficient size to develop fully the stiffener in bearing and they shall be so placed as to completely seal the stiffener ends against entrapment of moisture. Welding transversely across the tension flanges of beams or girders which have a flange stress of more than 74 per cent of their designed capacity, shall not be permitted. At locations of higher stress, wedge fillers shall be incorporated in conjunction with longitudinal welds.

Intermediate stiffeners shall fit sufficiently tight to excide moisture after being painted. Fillers under stiffeners shall fit within 1.5 mm at each end. Crimped stiffeners angles or tees shall be properly bent to a steel template, and they shall have full contact bearing against the flange and the web plates.

(5) Holes for Unfinished Bolts

(a) General

All holes shall be true to the shape and size specified, clean-cut perpendicular to the axis of the member and free from all burrs and distorted, torn or ragged edges.

The minimum distance from the centre of a hole to a sheared edge shall be 38 mm, and the minimum distance to a planed or rolled edge shall be 1.5 times the diameter of the bolt specified for such hole, except as hereinafter provided or otherwise indicated in the plan. The edge distance for lace bars shall be not less than 1.6 times the diameter of the rivet or bolt.

(b) Type

When reaming or drilling is not specified in the contract, full size punched holes in low carbon and low alloy steels may be acceptable, provided the thickness of the metal does not exceed the diameter of the hole to be punched, and provided no more than 5 thickness of metal are to be connected. When there are more than 5 thickness of metal or when any of the material is thicker than the diameter of the hole, all of the holes in the material composing such connections shall be formed by subpunching (or subdrilling) and reaming or by drilling from the solid, as hereinafter specified. Stress-carrying high-carbon steels, non-ferrous metals and alloys 13 mm in thickness or less shall be subpunched (or sub-drilled) and reamed. Where such metals are of greater thickness the holes shall be drilled from the solid with all parts assembled. Railing Sections may be jig drilled full size.

When general reaming is specified in the contract for low carbon and low alloy steels, all bolt holes, including connection holes to main members, shall be subpunched (or subdrilled) and reamed, or drilled from the solid; except for the following, which may be full punched:

- Holes for unfinished bolts, or plug welds.
- Holes in expansion and deflection devices, stringer diaphragms and railings.
- Holes in laterals and lateral plates; away frames other than in towers of bents; brackets; sole, bearings or anchor plates; and grillages.

(c) Punched Holes

The diameter of full sized punched holes shall be 1.5 mm larger than the nominal diameter of the rivet or bolt. The diameter of the die shall not exceed the diameter of the punch by more than 1.5 mm.

All holes shall be so accurately punched that, after the assembly of the component parts of a member, and before any reaming is done, a cylindrical pin whose diameter is 3 mm less than the nominal diameter of the punched hole shall pass freely through at least 75 per cent of the holes in any group. Correspondingly, a pin whose diameter is 5 mm less than the nominal diameter of the punched holes shall pass freely

through all holes in any group. Material falling to meet either of the above requirements shall be rejected. Reaming shall not be permitted as a corrective measure.

(6) Holes for Turned Bolt

The diameter of holes for turned bolts shall be 0.4 mm larger than the diameter of the bolt. If the bolts are to be inserted in the shop, the holes may be either drilled from the solid, or subpunched and reamed. If the bolts are to be inserted in the field, the holes shall be subpunched or subdrilled in the shop and reamed in the field. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled and securely fastened together. No offsets shall be permitted in holes for turned bolts.

(7) Slotted Holes

Slotted holes shall be securely located, true to planned dimensions, where full size slot punches are not used for this purpose, the holes shall be made under size and subsequently finished to true size and shape by chipping grinding or filing.

(8) Bolts

(a) Unfinished Bolts

Unless otherwise specified, all bolts for steel construction shall be unfinished and shall have hexagonal heads, hexagonal nuts and lock washers. The length of the bolt shall be such that, after placement, it will project through the nut not less than 3 mm nor more than 9 mm. The material for and the manufacture of bolts shall conform to the requirements of IS 1364 or IS 3757 as appropriate.

(b) Turned Bolts

The heads and the nuts shall be hexagonal. The bolt shall be machined from a hexagonal bar, the size of which shall be the same as the bolt head. The shank of the bolt shall be turned and given a smooth finish to exact diameter. The length of the unthreaded portion of the bolt under the head shall be 3 mm greater than the thickness of material it is to pass through. The diameter of the unthreaded portion of the bolt shall have a diameter at least 2.4 mm less than the diameter of the unthreaded portion of the bolt, and it shall be the nearest standard bolt size. The threads shall extend from the end of the bolt to within 1 thread distance form the shoulder. Washers 6 mm in thickness shall be used under all nuts, and the hole in the washer shall be the same size as the reamed or drilled hole.

(c) Anchor Bolts

Anchor bolts shall be the swage type and shall have hexagonal nuts. Bolts for expansion joints shall be provided with 2 nuts. Those portions of bolts which extend above masonry or concrete shall be painted 1 shop coat of paint.

(d) High Strength Friction Grip Bolts

High Strength friction grip bolts shall comply with IS 3757.

All load indicators shall be suitably marked for identification purpose and shall be of standard black, lightly oiled, finish and shall be packed prior to dispatch, by the manufacturer, in waterproof containers and shall be stored in those containers under cover until required for use in the works.

Only general grade load indicators shall be used with general high strength friction grip bolts.

Each high strength friction grip bolt when installed in the works shall be complete with one washer placed under the nut and one indicator placed under the bolt head and each bolt shall be tightened at all stages by rotating the nut only, the bolt head being completely restrained against rotational movement.

Alternatively, in joint where accessibility is limited to the extent that bolts must be tightened by rotating the bolt heads, then washers shall be laced the bolt heads and both load indicators and nut face washer shall be placed under the nuts. In these cases each bolt shall be tightened at all stages by rotating the bolt head only, the nut being completely restrained against rotational movement.

All high strength friction grip bolts shall first be tightened sufficiently to secure the structural steel work during its erection or assembly. Following completion of the erection or assembly of each portion of the structural steelwork those bolts shall be finally tightened until the gaps between the load indicators and either the bolt heads or the nut face washers have been reduced to:

(i) 0.40 mm where load indicators are fitted under the bolt heads

(ii) 0.250 mm where load indicators are fitted under the nuts and beneath nut face washers.

The bolt may be tightened by a part-torque part-turn method. The part-torque tightening for bedding down shall be in accordance with BS 4604: Part 1 except that it shall be carried out by a calibrated tightening device such as a torque-controlled manual wrench or power

operated wrench. The bending torque to be applied to the bolts shall be as given in Table 22.1.

Table 22.1: Preliminary Tightening of Nuts

Nominal dia of bolt mm	Bedding torque ± 10 percent Nm
16	80
20	160
22	210
24	270
27	340
30	460

After bedding down of the joints, each nut and the protruding threads of the bolt shall be permanently marked to record their relative positions. The nuts shall then be tightened to the approval of the Engineer by the part-turn of the nut method in accordance with BS 4604: Part 1.

2205. CASTING AND HEAT TREATMENT

(1) Foundry Practice

Pattern for casting shall be furnished by the Contractor. They shall be constructed to produce a finished casting in true conformity to the dimensions and details shown in the plan. All sharp angles shall be boldly filleted. Fillets shall be of such size that there is no reduction in planned clearances due to their addition. External corners on all castings, except ornamental type, shall be rounded to a 5 mm radius. Proper allowance for shrinkage shall be made in all patterns. Sufficient materials shall be provided on all surfaces which are to receive a finish so that, after finishing, the casting will be the planned size, and the finished surfaces will be true, free from pockets, sand intrusions, or other defects. Draft provided shall allow the plan dimensions and shall not reduce the thickness of metal specified. All patterns shall be painted, indicating in different colours, the metal, coarse and finished surfaces.

Spilt cores shall not be permitted between unfinished surfaces of restricted clearance. The number and spacing of chaplets shall be such that the strength of the casting is not impaired by their use.

The casting shall be accomplished by a method that will ensure the complete filling of all corners, arises and edges. Castings requiring undercut surfaces shall be cast by the “lost wax process” or equivalent. Where practicable, casting having one machined surface shall be cast with the surface down. Metal from different melts shall not be permitted in the same casting.

Casting shall not be withdrawn from the mould until they have properly cooled. Quenching of casting to speed up the cooling shall not be permitted.

All casting shall be thoroughly cleaned of moulding and core sand blasting or by other approved methods. All high spots and rough edges resulting from pouring connections shall be ground smooth.

All casting shall ring true when suspended and struck with a hammer. When ordered by the Engineer, the soundness of the casting shall be further tested by drilling, planning, magnetic particle test or X-ray.

Any structural defect in a casting such as blow holes, pipes sand holes, cracks, checks, slag inclusions, cold shuts, unfilled arises, warped surfaces, or deformations from core or flask movement shall be cause for rejection.

Castings with minor defects shall not be repaired until the Engineer has given his permission. The method employed in such repair work shall be approved by the Engineer.

(2) Heat Treatment

The term "heat treatment" shall mean any method of intentionally and systematically applying heat, at a temperature below the melting point, to any casting after it has cooled. This heat may be applied one or more times irrespective of cooling the procedure.

The term "annealing" shall mean either normalizing (air cooling) a casting or full annealing (furnace cooling) a casting.

Full annealing shall consist of a heat treatment in which the casting is heated slowly to the proper temperature above the critical range, maintained in such temperature for the required time, and allowed to cool slowly in the furnace until the temperature has fallen to 260 degrees F or less. The casting may then be withdrawn from the furnace and air cooled. The furnace temperature shall be controlled by pyrometers.

All other casting shall be annealed when so specified in the contract.

All forgings, and such other steel Sections as may be required by the contract, shall be full annealed. Other steel members, except primped web stiffeners, that have been partially-heated shall be full annealed unless otherwise authorized by the Engineer

2206. WELDED CONSTRUCTION

(1) General

Welding shall be generally in accordance with IS 1024 and relevant British Standards as further amplified in the following Sub-clauses.

(2) Materials

Welding materials unless specified in the contract or agreed by the Engineer shall comply with the appropriate Indian Standard listed below:

(a) IS 814 - 1991 covered electrodes for manual arc welding of carbon and carbon manganese steel (fifth revision).

(b) IS 814 - 1991 filler rods and wires for gas welding (second revision).

Classification and colour coding of electrodes shall be in accordance with IS 814-1991.

(3) Welding Equipment

Welding equipment shall comply with the appropriate Indian Standard listed below unless otherwise stipulated in the contract or agreed by the Engineer.

- IS 2635 – 1975: DC electric welding generators (second revision).
- IS 4804 (Part 1) – 1968: Single-phase transformers.
- IS 4804 (Part 2) – 1968: Single-phase rocker arm spot welding machines.
- IS 4804 (Part 3) – 1969: Single-phase spot and projection welding machine.
- IS 4559 – 1993: Single operator rectifier type DC arc welding power source (second revision).
- IS 2641 – 1989: Electrical welding accessories (first revision).

The welding plant and equipment employed on the works shall be sufficient capacity to carry out the agreed procedures and suitable for the types of electrodes in use. All necessary stagings and screens shall be provided for the welders, supervisors and inspectors and all plant and equipment shall be maintained in an efficient condition. Suitable tong test ammeters shall be provided for measuring the current, except only, when efficient means of so doing are incorporated as part of the welding plant.

The strength of the welding current shall be within the range recommended by the manufacturer of the particular electrode being used and shall be towards the upper limit of the range rather than the lower.

Welding shall wherever possible be carried out in covered workshops and under the specified conditions of temperature, where continuous supervision is exercised. Machine welding may be allowed where allowed

where approved machines are in use correctly controlled by qualified operators.

Site welding shall not be carried out unless prior written agreement from the Engineer has been obtained. All such welding shall be subject to 100% non-destructive testing.

(4) Qualification of Welders

All welding operators shall be qualified person in accordance with Clause 23 of BS 5135 and the names of all operators and details of their qualifications shall be submitted to the Engineer for agreement. Any operator whose standard of workmanship is unsatisfactory shall be immediately suspended. The operators shall be produced by the Contractor for re-testing and verification of his qualification once he has received further instruction in this respect. Routine testing of all operators shall be required in every six months.

(5) Workmanship

(a) Assembly

Material that is to be welded shall be free form loose mill scale, rust, or other foreign matter on the surface to be welded and for a distance of at least 50 mm on each side of the weld. The preparation of edges for welding may be by milling, chipping or cutting with a torch. All traces of overheated metal caused by torch cutting shall be removed. For this chipping to expose clean metal may be required. Grinding shall not be permitted on any surface or edge which is to be welded, unless the surface is subsequently thoroughly cleaned of carborundum and metal particles.

Members or parts which have been painted shall have all of the paint remove from the area which will be affected by the heat of the arc. This shall be accomplished by burning with a blow torch or blow pipe and brushing with a wire brush.

(b) Welding

Welding shall not be done in rain, snow or wind, or when the temperature of the metal is below 4^{o} C, unless satisfactory protection such as shelters, wind-breaks and heat is provided.

During moderately cold weather the use of small movable shelters and preheating the metal by means of blow torches will be in general satisfactory. When the temperature is below- 10^{o} C, the span or portion of structure under going welding shall be entirely housed in and heated to a minimum of 5^{o} C. The use of open salamanders for such heating shall not be permitted.

Welding procedures shall be such that distortion is reduced to the minimum practicable and local distortion is negligible in the final structure.

All welding procedures including those items listed in Clause 20 of BS 5135 shall be submitted to the Engineer in advance for agreement. All welding procedure submitted for agreement shall have previously been approved by an Independent Inspector, from authentic documented experience gained with welding of joints similar to that for which the welding procedure applies. Where no such approval is available, then the welding procedure shall be subjected to approval after testing in accordance with the requirement of BS 4870.

All welds shall be of the specified size and shape, and they shall be placed at the locations designated. Welds which are not in conformity with those required or welds which are defective, shall be chipped out and redone in an approved manner. Weld protrusions which interfere with later work or which present an uneven or unworkmanlike appearance shall be finished smooth by chipping and grinding. Deposited weld metal must be completely fused to all metal with which it is in contact. The weld shall be free of all pits, porous Sections, cold shuts, or slag inclusions. All pits and craters shall be filled and all ends shall be boxed.

An electrode of the proper size shall be selected for the weld desired. The electric current shall be adjusted for the electrode so that full fusion will be obtained without undercutting. Undercut welds shall be chipped back to bright metal and rewelded. The arc shall be kept uniform and steady and shall be applied in a manner which will fuse the metal without boiling, running or unnecessary spatter.

The placement of welds shall be such as to minimize shrinkage or distortion of the members. Members in which there is distortion caused by welding must be straightened to the satisfaction of the Engineer without structural damage to the member or to the welds.

Peening for welds shall not be permitted.

(c) Final Finish of Welds

The final finished surface of the weld shall be smooth and regular and shall conform as closely as practicable to the design requirements. All slag shall be removed from the finished weld. All flux deposit which may cause paint to rot shall be entirely removed. The entire surface shall be thoroughly wire-brushed before painting. If required by the Engineer, the final surface shall be finished smooth by chipping and grinding the weld deposit.

(d) Weld Inspection

Inspection shall be made during the welding process and after the weld is completed and cooled in accordance with IS 3600. All defects shall be entirely removed or repaired to the satisfaction of the Engineer. The Engineer shall designate at least 25 mm of every 2500 mm of welding for removal, to determine the penetration, fusion and porosity of the weld.

Plug borings shall be furnished when requested with the use of "X-ray" or magnetic-particle examinations may be made where the proper testing equipment is available. In such cases the inspection practice shall be in accordance with IS 1182 or IS 5334 as appropriate.

(6) Safety Precaution

Suitable shoes, helmets, hand shields, glasses, gloves, aprons, screens, canvas, wind shields and all other equipment necessary for the protection of the work, the welders, the helpers and the Engineer's Inspector shall be provide by the Contractor at his own expense. The provisions of IS 818-1968 Code of Practice of safety and health requirements in electric and gas welding and cutting operations (first revision) shall be observed.

(7) Procedure Trials

When directed by the Engineer and before fabrication is commenced, welding and flame cutting procedure trials shall be carried out using representative samples of materials to be used in the work.

The samples of material shall be selected and marked by the Engineer when the materials for the work are inspected at the mills.

Trials on material 20 mm thick shall be taken to include all material up to but not exceeding 20 mm thick. Trials on material 38 mm thick shall be taken to include material over 20 mm and up to but not exceeding 38 mm thick. Material over 38 mm thick shall be tested for every thickness increment of 6 mm.

The welding and flame cutting trials shall demonstrate to the satisfaction of the Engineer the procedures to be adopted in the fabrication of the work which shall include:

(a) Welding procedure in accordance with BS 5135 - 1984.

(b) The heat control techniques required to ensure that the flame cut surfaces of steel are free from cracks, local hardness, and any other defects which would be detrimental to the finished work.

The trials shall include specimen weld details representative of the actual construction which shall be welded in a manner simulating the most unfavorable conditions liable to occur in the particular fabrication. Where primers are to be applied to the work prior to fabrication, they shall be applied to the sample material before the procedure trials are made. After welding the specimens shall be held at a temperature not less than 10^{o} for a period of not less than 72 hours and shall then be sectioned and examined for cracks and other defects.

The following groups of tests as per BS 709 shall be carried out in accordance with Clause 621.

(i) Butt Welds

- Transverse tensile test
- Transverse and longitudinal bend tests
- Separate tests shall be performed in each case with the root of the weld in tension and compression respectively.
- Charpy V-notch impact tests BS 4360.
- Macro examination test.

(ii) Fillet Welds

- Fillet weld fracture test
- Macro examination test

(8) Use of Electrodes

Electrodes and fluxes shall be used in accordance with the manufacturers instruction.

(9) Butt Welds

Unless otherwise described in the contract, all butt welds shall be complete penetration welds made between prepared fusion faces.

In the fabrication of built-up assemblies, all butt welds in each component part shall be Engineer before the work commences.

Where automatic or semi-automatic process are used back gouging of deposited weld shall not be required where the Engineer is satisfied that the root run is free from imperfection.

Where butt welds are to be ground flush, there shall be no loss of parent metal. The final grinding shall be in the direction described in the contract.

Strud shear connector shall be welded in accordance with the manufacture's instructions.

In butt joints the root edges or root faces shall not be out of alignment by more than 0.125 times the thickness of the thinner material for material up to 12 mm thick or by more than 2 mm for thicker material.

Requirements for "run-on" and run-off" plates shall be as follows:

(a) One pair of run-on plates and one pair of run-off plates all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively of all butt welds. Unless otherwise required by the Engineer, approximately 1 in 5 pairs of run-off plates, for butt welds in tension flanges and1 pairs for other butt welds, shall be production test plates. The combined size of each pair of production test plates shall be either 225 mm, 300mm or 375 mm wide x 200 mm long as shown in Table 22.2 the length being measured in the rolling direction of the metal and at right angles to the weld.

Table 22.2: Sizes of Run-off Production Test Plates

Material	**Combined size (per pair) of run-off production test plates**		
	Plates up to 30 mm thick	**Plates from 30 mm to 75 mm thick**	**Plates over 75 mm thick**
IS-1915	300 x 200	375 x 200	Sizes to be agreed by the Engineer

(b) Butt welds shall run the full length of the joint and extend at full weld profile for a minimum distance of 25 mm into the run-off plates, and for a minimum distances of 200 mm, 275 mm, 350 mm respectively into the 225 mm x 200 mm x 200 mm run-off production test plates.

(c) On completion of the welds the run-off production test plates shall not be removed until they have been marked in a manner agreed by the Engineer to identify them with the joints to which they are attached.

(d) When removing the run-on and run-off plates by flame cutting the cuts shall not be nearer than 5 mm to the sides of the parent metal and the remaining metal shall be removed by grinding or other method agreed by the Engineer.

(e) Specimens for the following tests to be carried out in accordance with Clause 621 shall be selected from the run-off production test plates by the Engineer:

(i) Transverse tensile test(s): The number of test shall be sufficient to cover the full thickness of plate.

(ii) Transverse bend test

(10) Camber

Main girders shall be fabricated to the cambers shown on the Drawing. Plates shall be prepared to produce a profile which approximates to a parabolic curve, from the supports to the midspan point of the girder.

2207. FIELD ERECTION REQUIREMENTS

(1) Handling and Storage of Materials

Structural metals shall be carefully unloaded manually or by means of suitable equipment so as to avoid damage to the materials or their painted surfaces. Under no circumstances shall structural steel be dropped or skidded off cars or vehicles, nor shall it be dragged over the ground. Beams and girders shall be transported and handled in upright position. Pin holes, or other field connection holes, shall not be used as places for "hook-on".

Material not to be placed directly in the structural shall be stored above probable high water, on skids or platforms in a manner that will prevent distortion in the members or the accumulation of water or dirt on such members. Beams and girders shall be stored in an upright position and securely stored. Provision shall be made to protect all metals against corrosion.

All damaged metals shall be rejected.

(2) Preparation for bearing area

Before placing column bases, bed plates or shoes and the bearing shall be prepared to proper elevation.

(3) Flasework

(a) Design

The requirements of Section 1800 shall apply insofar as they are applicable together with the following modifications and additions: Steel shall be assumed to weigh 8000 kg per cubic meter. In addition to the superimposed dead load the falsework shall be designed so as to

carry safely the weight of any equipment which it may be required to support.

(b) Plans for Falsework

The Contractor shall prepare plans and design of the falsework. When so requested these plans shall be submitted to the Engineer for his approval, before the construction of the falsework is started. The Engineer's approval of such plans or his acquiescence in the work shall not relieve the Contractor of responsibility for satisfactory results.

(c) Construction

Falsework construction shall conform to the requirements of Section 1800 insofar as they are applicable, together with the following modifications and additions. Falsework bends shall be so constructed as to provide a minimum clearance of 600 mm between the falsework caps and the lower members of the structure which are to be supported thereon to provided ample space for the jacking and riveting of such members.

(d) Removal

The requirements for the removal of falsework shall be as provided in Section 180 insofar as they are applicable.

(4) Straightening Bent Metal

Straightening of bends in main structural members shall not be permitted in the field. Such members shall be return to the fabricator for proper repair or replacement.

Bent material shall be straightened, to the satisfaction of the Engineer and under his direct supervision, before such material is incorporated into the structure.

The straightening of bends shall be done by methods that will not produce embrittlement, fracture or damage. All material shall be straightened cold when practicable. No plated, galvanized, enameled, heat treated aluminium and similar metals shall be heated. When metal of these types can not be satisfactorily straightened cold, they shall be returned to the fabricator for repair or replacement.

Mild steel and structural grade steel may be heated when necessary to accomplish straightening. Other carbon steel and low alloy steels shall not be heated unless specific approval is granted by the Engineer. Heating and straightening shall conform to the requirements of Sub-clause 2203 (3) (g).

2208. ASSEMBLING AND BOLTING

(1) General

All field contact surfaces, including shims, which have not been given a shop coat of paint, shall be thoroughly cleaned and given a coat of the specified "soap coat" paint, except when such surfaces are to be completely sealed by welding. Assembly of Sections shall be made while the contact paint is still plastics. All surfaces of metal which will be inaccessible after erection shall be thoroughly cleaned of all foreign matter, spot coated and field painted in accordance with the provisions of Clause 2209.

Immediately before assembly, all pins shall be thoroughly cleaned and given a coat of red lead. The pins shall be inserted into the holes before the red lead is dry and the pin nuts are drawn tight. The exposed threads shall be effectively burred or checked at he face of the nut.

Fabricated Sections which have been assembled, reamed, and matchmarked in the shop shall be erected in exact conformity with such match marks. The interchanging of parts shall not be permitted.

Steel structures shall be assembled to correct line and elevation before any welding is undertaken.

(2) Trusses

Trusses spans, except those portions erected by the cantilever method, shall be erected on blocks so placed as to provide required camber. The camber shall be secured by adjusting all panel points to the elevations as shown in the plan or as directed by the Engineer.

Care shall be taken that trusses are in perfect alignment and that all milled ends of compression members are in full contact. The spans must be fully erected, including all portals, laterals, struts and sways, and all field connections, except connection for stringers, rails and expansion devices shall be securely drift pinned and bolted before any of these is permitted. In case of cantilever spans, the Engineer may permit welding portions of the anchor spans before the cantilever arms are completely erected.

(3) Simple Girders

Simple girder and beam spans shall be accurately set to square or skew as required in the Drawing, with all diaphragms drift pinned and bolted in place before field welding is permitted. Truss, girder or beam spans designed continuous over supports shall be completely erected before any welding is permitted.

Unless otherwise provided in the contract, suspended spans shall not be until the adjoining spans are completely erected. No welding shall be permitted until the erection is complete.

For continuous or cantilever spans, the number of fitting-up bolts and drift pins required shall be determined by the Engineer for the stresses developed in the various joints during erection. Drift pins and bolts shall be used in equal proportions and shall be located as to hold effectively the joint members in close contact and in correct position during all welding operations.

Erection washers not less than 5 mm in thickness and not less than 50 mm in diameter shall be used with all erection bolts.

(4) Welding

Connections to be welded shall be held in tight contact by means of bolts and clamps before welding and the welding shall conform to the requirements of Clause 2206.

(5) Bolted Connections

Contact surfaces shall be thoroughly cleaned of rust, mill scale, dirt, grease, paint lacquer, or other foreign material before assembly. All bolts shall be installed with a hardened washer under nut or bolt head whichever is the element turned in tightening. Bolts may be tightened by any method to the required tension. The torque value needed to develop the required bolt tension shall be determined by the Engineer. Bolt tension shall be checked at locations determined by the Engineer in the presence of the Contractor and in such manner that the Engineer can read the torque gauge. Other methods of determining bolt tension may be used, provided the prior approval of the Engineer is obtained in writing. Nuts shall be positioned whenever practicable on the side of the Engineer which will not be visible from the traveled way. Nuts for bolt which can be partially bedded in concrete shall be positioned on the side of the member that will be encased in concrete. Bolts up to 6 mm larger in diameter of those shown in the Drawing may be used provided that the required clearance and edge distance are not reduced below those required for the lager bolt.

2209. PROTECTION AGAINST CORROSION

(1) Preparation of Surface to Receive Paint

Before paint is applied to any surface other than metal-coated surfaces the appropriate surface preparations as described in the contract shall be carried out in accordance with the following:

(a) Bare Metal Surfaces

Blast cleaning shall be carried out in accordance with BS 4232 to the quality of surface finish as described in the contract. The maximum grade of abrasive permitted shall be as specified in Table 2 of BS 4232. Non-metallic abrasives shall not be permitted. The abrasive used for blasting shall be free from contamination and any recovered material shall be cleaned to the satisfaction of the Engineer before re-use. The maximum amplitude (peak to trough) of the blast-cleaned surface shall not exceed 0.10 mm. Surfaces shall be protected within the following time of having been blast cleaned:

- 2 hours if humidity in air $\leq$ 85%
- 4 hours if humidity in air $\leq$ 75%
- 6 hours if humidity in air $\leq$ 60%

A sample blast-cleaned steel panel measuring not less than 150 mm x 150 mm x 6 mm adequately protected by sealed clean polythene wrapping shall be submitted to the Engineer for approval before any works is put in hand. The approved sample shall then be retained by the Engineer's inspectors for comparison with the prepared steel work.

(b) Mechanical Cleaning.

Mechanical cleaning shall be carried out by power-driven tools, such as carborundum grinding discs, chipping hammers and needle guns, followed by steel-wire brushing and dusting to remove all loosened material. Excessive brushing of the metal through prolonged application of rotary wire brushes shall be avoided. Surfaces shall be protected within the time as specified above in Sub-clause 2209 (1) (a) after they are mechanically cleaned.

(c) Welds and Areas Affected by Welding

Unless otherwise described in the contract, welds and surfaces which have been affected by welding shall be prepared for painting by the same process as described in the contract for the adjoining metal.

(d) Painted Surfaces

Painted surfaces shall be cleaned of all dust immediately prior to the application of further paint. Any loose paint and rust shall be removed. Areas contaminated by oil and grease shall be cleaned with white sprit. Where required by the Engineer, the whole surface shall then be cleaned by washing down with a solution of an approved liquid detergent followed by rinsing with clean fresh water and allowed to dry thoroughly before paint is applied.

(2) Treatment of Surfaces

(a) High Strength-Friction Grip Bolt Interfaces

The treatment of interfaces to be jointed by high strength friction grip bolts shall be as described in the contract. Paint work shall be stopped off at a distance of 75 mm from the joints and all interfaces shall be cleaned by wire brushing before assembly.

(b) Untreated Surfaces

Steel work surfaces which will have concrete cast against them shall be left unpainted. The surfaces shall be thoroughly wire brushed to remove loose rust, mill scale and surface contamination.

(3) Storage of Paint

Paint shall be stored in sealed containers in a lock-up store in accordance with the manufacturer's instructions. Plant which has not been used within the "shelf life" period specified on the containers or within 12 months of the date of manufacture, whichever is the lesser, shall not be used.

Paint from painter's kettles shall be returned to store at the end of each working period where it shall be kept in a sealed container. Before it is re-issued it shall be thoroughly mixed and no fresh paint or thinners shall be added.

(4) Application of Paint

All paint shall be supplied from the store to the painters ready for application. The addition of thinners or of any material shall be thereafter prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by skilled painters under competent supervision.

Paint shall be applied to dry surfaces which have been prepared in accordance with Sub-clause 2209 (1). The interval between preparation of the metal surface and the application of the first priming coat of paint shall be in accordance with the relevant requirements of Sub-clause 2209 (1).

Paint shall not be applied under the following conditions:

(a) When the ambient temperature falls below 4oC or the relative humidity rises above 90o except if otherwise stated in the manufacturer's instructions.

(b) During rain or mist

(c) When condensation has occurred or is likely to occur on the steel.

Each coat of paint shall be applied by the method instructed by the manufacturer to produce a continuous film paint of uniform and even thickness. As soon as the first priming coat has dried, an extra stripe coat of paint shall be applied by the brush to edges, corners, crevices, bolt heads and welds, using paint of similar composition to the subsequent undercoat, but in a contrasting shade. Successive coats shall have different shades for identification and each coat shall be thoroughly dry before the application of a further coat.

The total dry paint film thickness of the paint system on bare steel surfaces and on metal coated surfaces shall be as described in the contract. The dry paint film shall be measured by Elcometer or other instrument approved by the Engineer.

In order to obtain the dry film thickness specified, the Contractor shall ensure that the coverage rate given by the manufacturer shall enable this thickness to be attained.

Wet film thickness gauges may be used for checking but shall not be permitted as a means of predicting the dry film thickness.

Unless otherwise agreed by the Engineer the paint system applied at he works shall be applied under cover, in controlled conditions, at the fabricator's works. One undercoat plus one finishing coat shall be applied at Site within the time limit stipulated by the paint manufacturer.

No paint shall be used after the expiration of the "pot-life" stipulated by the manufacturer. The paints of expired "pot-life" shall not be mixed with fresh paint or have thinners added to them.

(5) Storage of Painted Steelwork

Painted steel work which is to be stored prior to erection shall be kept clear of the ground and shall be laid or stacked in an orderly manner that will ensure that no water or dirt can accumulate on the surfaces. Suitable packing shall be laid between the layers of stacked materials. Where cover is provided, it shall be ventilated.

Prime painted steelwork which is to be stored out-doors or transported prior to fabrication shall not be exposed for periods longer than the following, before being over coated:

Blast primers - 1 coat	maximum 8 weeks, including 2 weeks of this time out doors.

(6) Repair to damaged Surfaces

Areas of paint which have been damaged during handling, storing, loading and off-loading, transportation, erection and construction shall be cleaned to bare metal, and the edges of the undamaged paint leveled with sandpaper.

The full specified painting system shall then be re-applied and the new paint shall overlap the existing paint by at least 50 mm all round the affected area.

(7) Painting of Joints

As soon as possible after joints have been made and passed by the Engineer the parent and joint material, exposed parts of bolts, nut washers, weld and weld affected areas shall be prepared as stated in the contract and brought up to the same state of painting as the adjoining surfaces.

(8) Painting Methods

Coat of paint in a system of painting shall be applied each by one of the following methods:

(a) Brush

(b) Roller (for shop painting only), supplemented by brush where necessary.

(c) Air pressure spraying

(d) Airless spraying

(9) Protective Systems

The Contractor shall furnish the Engineer with duplicate copies of the manufacturer's data sheets for the paints he proposes to use. Following the Engineer's written instruction the requirements of the paint manufacturer's data sheets shall be adopted for the works.

Where called for by the Engineer the Contractor shall carry out paint application procedure trials, either at the fabricator's works or at Site as appropriate, with the equipment and labour to be used in the works. The Contractor shall supply suitable blast cleaned steel and sufficient paint for the trials and must demonstrate his ability to apply each coat of paint of a designated paint system in accordance with the Specification and the paint manufacturer's data sheet. No painting of the contract steelwork shall be permitted until the procedure trials have been complete to the satisfaction of the Engineer. Any adjustment to the registered paint formulation shown to be required by the trials, other than an increase in the amount of thinners, must be agreed by the Engineer and made at the paint manufacturer's work before the final stage of a paint procedure trial and before delivery of the first batch of paint.

All requirements of the paint manufacturer's data sheets shall be complied with. Paint shall be supplied from the Contractor's paint store to the painters ready for application, the only adjustment of formulation being as provided in paragraph 2 above. Any addition of thinners must be made in the store under the supervision of the Engineer and only as allowed under the manufacturer data.

(a) Superstructure Steelwork

(i) Steelwork Members

Surface preparation at works: Blast clean to 1st quality (including joint areas) BS 7079.

Painting: as shown on the following Table:

Painting at works	**Coat**	**Paint**	**Method of application**
	1st	**Zinc Chromates/Red Oxide Blast Primer**	**Airless Spray**
Excluding joint	(Stripe to edges etc.)	Zinc Phosphates epoxy ester undercoat	Brush (Airless Spray grade paint)
	2nd	As Stripe coat	Airless Spray
	3rd	As Stripe coat	Airless Spray
	4th	As Stripe coat	Airless Spray
At site	5th	Miscaceous Iron Oxide Phenolic/tung oil undercoat	Brush
	6th	Miscaceous Iron Oxide Phenolic/tung oil Finish Dark Grey	Brush

(ii) High Strength Friction Grip Bolted Joints

a. Cover Plates

Surfaces preparation at work:	Blast clean to 1st quality BS7079.
Painting at work (excluding : Contact surfaces)	One coat, Zinc Chromate/Red Oxide Blast primer applied by Airless Spray

Surfaces preparation at site:	Before assembly, wire brush contact surfaces by hand After assembly, wire brush works coat of blast primer.
Painting at site (after bolting):	Coats 1, Stripe and 2 to 6 as (i) above but all applied by brush and coat within 4 hours of wire brushing works blast primer. Minimum total dry film thickness at stripe coated areas: 250 micron.

b. Contact Surfaces of Steelwork Members

Surfaces preparation at site:	Before assembly, mask around contact surface apply paint stripper and scrape off works coat of blast primer. Wash off stripper and wire brush by hand when dry.

c. Bolts, Nuts and Washers

At site:	Removal oil than prepare surface and paint as for cover plates above.

(iii) Painting System for Repairs to Damaged Surfaces

Coats 1, Stripe (if relevant) and 2 to 6 as above but all applied by brush.

(b) Parapet and Guard-rails

Surface Preparation:	Picking
Metal Coating:	Hot-dip galvanizing Minimum of galvanizing 1610 g/m^2 or minimum thickness 85 micron.

(10) Metal Coatings

Unless otherwise specified by the Engineer procedures for applying metal coating shall bein accordance with the following:

(a) BS 729 Part 1: Hot-dip Galvanised Coating
Part 2: Sheradised Coating

Metal coating to BS 729 shall only be applied to components of a tensile strength up to and including that of General Grade HSFG bolts unless specified by the Engineer.

(b) BS 2569 Part 1 Sprayed metal Coatings (Zinc and Aluminium). The nominal thickness of coating to be 100 micron.

(c) BS 3382: Part 1 and 2. Electorplated Coated on Threaded Components (Cadmium and Zinc). This British Standard shall be deemed to cover the electroplating of components up to and including 36 mm diameter. The minimum thickness of coating to be 5 micron.

Where a metal coating is required only on part of an assembled Section it shall be applied before the rest of the Section receives its priming cot.

(11) Etch Primers and Blast Primers

Etch primers and blast primers shall be suitable for continuous spray application. They shall not be used on phosphated steel nor shall they be overcoated with zinc rich primers.

2210. MEASUREMNT

The structural steel shall be measured in tonne and shall be based on the net weight of metal in the fabricated/erected structure computed on the basis of nominal weight of the elements. While computing the weight, the specific gravity of steel shall be adopted 7.85 tonne per cubic metre. The weight shall be determined from the dimensions shown on the Drawing. The weight so measured shall be inclusive of weld fillets and weight of protective coatings, if any.

All operations like cutting, bending, straightening, heat and cold treatments, machining, temporary and permanent erection, connection, bolts, nuts and washers, welding, painting and protection against corrosion and other ancillary and incidental operations shall be deemed included in the weight of the steel structure as measured above

2211. PAYMENT

The structural steel as measured shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 and also for the cost of all operations required for fabrication, connections, oiling, painting, temporary erection, inspection, tests and final erection including all other ancillary and incidental works needed to compete the work as per these Specifications and/or directed by the Engineer.

SECTION 2300 – TIMBER CONSTRUCTION

SECTION 2300 –TIMBER CONSTRUCTION

2301. SCOPE

This Section covers timber construction of permanent works at locations as shown in the Drawing. The work specified herein may not be relevant not for the temporary facilities and formwork (centering and shuttering).

2302. MATERIALS

(1) Timber

Timber shall be straight and free form twist, sapwood, shakes, dead and loose knots, worm holes, other holes, signs of decay and other defects, and seasoned and shall comply with the requirements of IS 883-1994 The Engineer shall inspect and stamp each timber to be used as structural members. The natural moisture content of any untreated timber delivered to site shall not exceed those as recommended by IS 287-1993. When timber is specified as unsawn it shall be cut above the ground swell and shall taper from butt to tip. A straight line drawn from the centre of the tip to the centre of the butt shall not fall outside the centre line of the piece at any point more than 1% of the length of the piece. When the timber is specified as sawn it shall be sawn true and square to the full dimensions. When timber is specified as wrot it shall be finished with a plane, smooth and true to dimensions on the faces so specified.

(2) Hardware

Hardware shall consist of bolts, with the necessary nuts and washers, timber connectors, drift pins, dowels, nails, screw nails, coach bolts, spikes and other metal fasteners. They shall be galvanised or ungalvanised as specified. Bolts, nuts and washers shall be mild steel and comply with IS 1363-1992. Timber connector shall be of the type shown on the Drawing. Drift Pins and dowels shall be mild steel. Nails shall comply with IS 723-1972. Screw nails and screws shall comply with IS 451-1972/IS 2585-1968. Coach bolts shall comply with IS 2609-1972. Spikes and other metal fastenings shall be mild steel.

(3) Timber Preservation

When described in the contract or shown on the Drawing timber shall be treated with preservative in accordance with the Indian Standard Code of Practice for the preservation of timber IS 401-1982.

(4) Galvanizing

When described in the contract or shown on the Drawing, all hardware shall be galvanised in accordance with the Indian Standard Recommended

Practice for Hot-Dip Galvanising or Iron and Steel: IS 2629-1985 and IS 1367 Part 13-1983: Hot Dip Galvanised Coating on threaded Fasteners. The Engineer may require galvanised hardware to be tested in accordance with IS 2633-1986.

(5) Flashing

Flashing shall be galvanised sheet of the gauge shown on the Drawing or described in the contract. It shall comply with the requirements of IS 277-1992: Galvanised Steel Sheets (Plain and Corrugated). The coating shall be of 750 Grade as specified in IS: 277-1992.

2303. CONSTRUCTION

(1) Handling and Storage of Materials

Timber shall be stored in piles at the site unless it is to be immediately incorporated in the structure. It shall be stacked so as to allow free air circulation and inspection on skids above the ground and standing water. It shall be protected from the sun to prevent warping. It shall be handled in a manner that will avoid injury or breakage. Treated timber shall be handled with rope slings. Cant hooks or other sharp instruments shall not be used. Undue injury during handling will be cause for rejection. Flashing, hardware, preservatives and other material shall be stored under cover in such a manner as to obviate deterioration.

(2) Framing

All timber shall be accurately cut and framed to a close fit and shall have even bearing over the entire contact surfaces. No shimming shall be permitted in making joints. Holes for drift pins and dowels in untreated timber shall be bored with a bit 1.5 mm less in diameter than the pin or dowel. Holes for drift pins and dowels in treated timber shall be bored to the same diameter as the pin or dowel. Holes in small timbers for spikes may be bored with a bit with the same diameter as the smaller end of the spike, when necessary to prevent splitting. All bolts shall be fitted with washers. Groundsills shall be firmly and evenly bedded in solid material. Posts shall be framed true and have full even bearing on the sills, caps shall be framed true and have full bearing on the posts or piles. Bents shall be properly aligned before bracing is placed. The minimum distance between the outside bolt and the end of any brace shall be 200 mm. In placing beams and/or stringers for bridge decks the better edge shall be place downwards. The top of beams and stringers after placing shall not vary from a plane more than that will permit bearing of the superstructure timber on all the beams and/or stringers. Kerbs and railings shall be accurately framed and aligned so that on completion they present a smooth visual line vertically and horizontally. Floor planks shall be laid such that no joints will occur over any one stringer or beam close than every third plank. No planks other

than required to fill out skews, shall be less than 2 metres in length and at least 50% of the planks shall be 5 metres or more in length. Close boarded floor planks shall be laid longitudinally breaking joint by at least 600 mm. They shall be secured in place by barbed nails, screws or coach bolts as shown on the Drawing, or described in the contract. These fastenings shall be spaced at not more than 250 mm and be staggered. Two fasteners shall be placed at each end of each plank.

2304. TESTS AND STANDARDS OF ACCEPTANCE

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer

The work shall conform to these Specifications and shall be to the true lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

2305. MEASUREMNT

Depending upon the nature of work, the quantities shall be measured in numbers, in the units of volume, area, or length as specified in the contract.

2306. PAYMENT

The quantities measured as provided above shall be paid at the contract unit rate applicable for the particular type of work. The Contract unit rate shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.

SECTION 2400 – MISCELLANEOUS STRUCTURES

SECTION 2400 –MISCELLANCEOUS STRUCTURES

2401. GABIONS

(1) Scope

This Clause covers the furnishing of materials and construction of gabion works that may be required to act as buttresses, retaining walls, catch wall, stream or river training structures, check dams within gullies, or where placed as mattresses, to prevent stream or gully erosion.

(2) Materials

(a) Stone

Stones used for filling the gabion boxes or mattresses shall be clean, hard, sound, unweathered and angular rock fragments or boulders. The specific gravity of the stone shall be not less than 2.50 and the stones shall not absorb water more than 5 percent when tested as per IS: 1124. The length of any stone shall not exceed three times its dimension of the mesh of the crate. However smaller size of stones as spalls shall be allowed for filling voids and its volume including voids shall not be more than 20 percent of the total volume of the stone. Before filling any gabion boxes and mattresses the Contractor shall submit representative samples of the rock he proposes to use in the gabion for approval by the Engineer. Further representative samples shall be submitted for approval each time when there is a change in the type and strength of the rock.

(b) Gabion

Gabions shall consist of steel wire mesh crates. The steel wire shall be mild steel wire complying with NS 169-2045. All wires used in the manufacturing crates and diaphragms, binding and connecting lids and boxes shall be galvanized with an heavy coating of zinc by an electrolytic or hit dip galvanizing process. The weight of deposition of zinc shall be in accordance with NS 163-2045. Zinc coating shall be uniform and be able to withstand minimum number of dips and adhesion test specified as per NS 163-2045. Tolerance on diameter of wire shall be $\pm$ 2.5 percent. The tensile strength shall be between 300 to 550 N/mm^2

The wire shall be woven into an hexagonal mesh with a minimum of 3 twists. All edges of the crates shall be finished with a selvedge wire at least 3 gauges heavier than the mesh wire. Gabions shall be manufactured in the standard sizes shown in Table 24.1 with mesh and wire sizes as shown in Table 24.2

Diaphragms shall be manufactured of the same materials as the parent gabion box and shall have selvedge wire throughout their perimeter. The number and size of diaphragms to be provided with each crate shall be as in Table 24.1. All crates shall be supplied with binding and connecting wire of the gauges shown in Table 24.2 of sufficient quantity to bind all diaphragms and closing edges.

Table 24.1: Standard Size of Wire Mesh Gabions

Dimensions in Meters (Prior to fill)	Number of diaphragms	Dimension of diaphragms in metres	Volume of crate in cubic metres
1 x 1 x 1	-	-	1
1.5 x 1 x 1	1	1 x 1	1.5
2 x 1 x 1	1	1 x 1	2
3 x 1 x 1	2	1 x 1	3
1 x 1 x 0.75	-	-	0.75
2 x 1 x 0.75	1	1 x 0.75	1.5
3 x 1 x 0.75	2	1 x 0.75	2.25
1 x 1 x 0.5	-	-	0.5
2 x 1 x 0.5	1	1 x 0.5	1
3 x 1 x 0.5	2	1 x 0.5	1.5
1 x 1 x 0.3	-	-	0.3
2 x 1 x 0.3	1	1 x 0.3	0.6
3 x 1 x 0.3	2	1 x 0.3	0.9

Table 24.2: Standard Size of Mesh and Wire in Gabions

Mesh opening mm	Mesh type	Thickness of mesh wire	Thickness of binding and connecting wire	Thickness of selvedge wire
(DxH)		S.W.G.	S.W.G.	S.W.G.
64 x 83	60 x 80*	11, 12	13, 14	8, 9
83 x 114	80 x 100	9, 10, 11	11, 12, 13	6, 7, 8
114 x 128	100 x 120	10, 9	12, 11	7, 6

** To be used in special cases subject to approval by the Engineer where stone of larger size are not available.*

Note: Equivalent diameter in mm as per NS 163-2045

SWG	6	7	8	9	10	11	12	13	14
mm	4.88	4.75	4.06	3.66	3.25	2.95	2.64	2.34	2.03

(3) Construction of Gabion

(a) General Requirements

Before filling any gabion boxes and mattresses, the Contractor shall submit samples of gabion boxes and/or gabion mattresses assembled, erected and filled with stones for approval which, when approved, shall be retained for reference and comparison with the gabions built as part of the permanent works. The size, type and location of the samples shall be as directed by the Engineer.

Gabion boxes and gabion mattresses shall be assembled, erected and filled with stones in the dry on prepared surfaces except as may be otherwise approved. Approval for assembling and erecting gabions in water shall be given only, if in the Engineer's opinion such a method will produce work which is otherwise in accordance with the Specification.

(b) Preparation of Foundation and Surface for Bending

The bed on which the gabion boxes or mattresses are to be laid shall be even and conform to the levels shown on the Drawing. If necessary cavities between rock protrusions shall be filled with material similar to that specified for gabion filling.

(c) Arrangement of Joints

(i) Walls

In walls gabion boxes shall be placed such that vertical joints are not continuous, but staggered. Aprons shall be formed of headers. If more than one unit is required to obtain the necessary width, unit of unequal length shall be used and the joints between should be staggered.

(ii) Channel linings

In channel linings, gabion box and mattress units shall be laid so that the movement of stone inside the mesh due to gravity or flow of water is avoided. Hence, on side slopes, unit shall be placed with their internal diaphragms at right angles to the direction of the slope and, on inverts, as far as possible, at right angles to the direction of flow.

(d) Assembly

Gabion boxes and gabion mattresses shall be assembled on a hard flat surface. After fabrication, unpacking or unfolding, they shall be stretched out and any kinks shall be removed. Creases shall be in the

correct position for forming the boxes or mattress compartments. The side and end panels shall be folded into an upright position to form rectangular boxes or compartments. The top corners shall be joined together with the thick selvedge wires sticking out of the corners of each panel. The tops of all sides and partitions shall be leveled except as may be appropriate to special units. The sides and end panels shall be tied together using binding wire of the thickness given in Table 24.2, starting at the top of the panel by looping the wire through the corner and twisting the wire together. Binding shall continue by looping the wire through each mesh and around both selvedges with three rounds which shall be joined tightly together by twisting and the end shall be pocked inside the unit. The diaphragms shall be secured in their correct positions by binding in the same way. The bindings wire shall be fixed using 250 mm long nose fencing pliers or equivalent approved tools.

The gabion boxes and gabion mattresses shall be laid in such a manner that the hinges of the lid will be on the lower side on slopes and on the outer side in walls.

Where mattresses are laid horizontally hinges shall not be placed on the downstream side as much as practicable.

(e) Filling

Except in the case of sack gabions, the crates shall be placed in their final position before filling commences. They shall be stretched to their full dimension and securely pegged to the ground or wired to adjacent gabion before filling. The vertical corners shall be kept square and to full dimension by inserting a steel bay of at least 20 mm diameter at each vertical corner, maintaining it in the correct final position throughout the filling process, and removing it when the crate is full. Before filling commences, the selvedges of the crate shall be bound to the selvedges of adjacent crates with binding wire. Where crates are being assembled in position in a wall the binding of the edges of each crate n the assembly process and the binding together of adjacent crates shall be carried out in the same operation.

Before filling with stone, gabion shall be anchored at one end or side and stretched from the opposite end or side by inserting temporary bars and levering them forward. The top and bottom shall be kept stretched by tensioning with tie wires attached to an anchorage or equivalent approved method until the gabion has been filled. The gabions shall be inspected at this stage but before filling with stone to ensure that the tie/wiring has been properly carried out and the gabion boxes or gabion mattresses are not pulling apart. Gabion boxes or gabion mattresses may be tensioned either singly or in the case of a long straight structure by staining a number of units together using an approved tensioning system.

The filling shall be carried out by placing individual stones into the gabion by hand in courses in such a manner that the stones are bedded on each other and bonded as in dry random rubble masonry as per Clause 2608. No loose stones shall be tipped into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaid stones shall not be permitted.

All 1m deep gabions shall be filled in three equal layers and 0.5 m deep gabions in two equal layers. Horizontal bracing wires made with the same bindings wire as used for tying shall be fixed directly above each layer of the stone in the compartments, the wires being looped round two adjoining meshes in each side of the compartment and joined together to form a double tie which shall be tensioned by wind lassing together to keep the face of the gabions even and free from bulges. Bracing wires shall be spaced horizontally along and across the gabions at distances not greater than 0.33 m. Where the upper faces of gabion boxes are not covered with further gabions vertical bracing wires shall be fitted between the top and bottom mesh using two tie wires per square metre of surface.

The ties shall be fixed to the bottom of the units prior to filling and tied down to the lid on completion. Where a double layer of gabion boxes is used to form an apron both upper and lower layers shall have vertical tie wires.

(f) Securing Lids

The gabion boxes and mattress compartment shall be over filled by 50 mm above their tops to allow for subsequent settlement. The lids shall then be tied down with binding wire to the tops of all partition panels. The lids shall be stretched to fit the sides exactly by means of suitable tool but due care shall be taken to ensure that the gabions are not so full that the lids are overstretched. The corners shall be temporarily secured first.

(g) Tolerance

On completion, the crates shall be completely and tightly filled, square, true to dimensions and the line and level shown on the Drawing. However the tolerance limit permitted in the length, height and width of the gabion boxes and mattresses as manufactured shall be $\pm$ 3 percent from the ordered size prior to filling. The tolerances on the wire mesh opening shall be $\pm$ 10% on the nominal dimension 'D' values as follows:

Mesh Type	Nominal dimension 'D' values
60 x 80	64
80 x 100	83
100 x 120	114

Dimensions are measured at right angles to the center axis of the opening and parallel to the twist along the same axis.

However, the number of opening per gabion box/mattress shall not be less than the nominal length divided 'D' on horizontal direction and nominal height divided by 'H' in vertical direction where D and H are per Table 24.2.

(4) Test and Standard of Acceptance

(a) The gabion wire shall be tested for mass, uniformity and adhesion of zinc coating and tensile strength of the wire itself. Failure of test results to comply with the specifications shall lead to the rejection of gabion wires. The test on the samples taken as per Table 24.3 from each lot of the G.I. wire received at the side of the work shall be carried out in accordance with NS 169-2045 and NS 163-2045.

Table 24.3: Scale of Sampling and Permissible Number of Defective

No. of coils in a lot	No. of coils randomly selected for sampling*	Permissible no. of defective coil
Upto 25	2	0
26-50	3	0
51-150	5	0
151-300	8	1
300 and above	13	1

**One sample per coil shall be tested in all respect*

(b) The stones shall be tested for specific gravity and water absorption. At least 3 set of tests shall be made for every source of material. The test results shall meet the specified criteria.

(c) In each two hundred cu.m. or part thereof one representative sample of completed gabion box mattress i.e. assembled, filled with stones and tied up in position shall be dismantled during the process of construction. The dismantling shall be made in such a manner that the quality of the surrounding work is least affected. The stones having least dimension more than or equal to the specified dimension shall be gathered at one place and the rest at another place. By displacement of water total volume of these specified stones shall be determined separately. Ratio of volumes of specified stone and voids including spalls to the volume of the total volume of the gabion box shall be worked out. The test result shall meet the requirement of the Specifications.

(d) The dismantled portion shall be made good by the Contractor at his own cost after completion of the test.

(5) Measurement

Gabion wire mesh for boxes and mattresses shall be measured in sq. metre. The boxes and mattresses shall be physically measured and be verified with their tolerances.

The binding wires, selvedge wire and tension wires shall not be measured separately. They are deemed included in the measurement of the gabion boxes and/or mattresses.

Stone filling in gabions including fixing of gabion in position, tying with binding wires and tension wires as specified shall be measured in cu.m.

(6) Payment

Gabion boxes, gabion mattresses, stone filling shall be paid as per respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work in accordance with these Specifications.

2402. CRIB WALLS

(1) Scope

This Section covers the construction of crib walls at locations shown on the Drawing or as instructed by the Engineer. Crib walls shall be constructed of reinforced concrete, timber or steel structural elements as shown on the Drawing and filled with compacted backfill material.

(2) Materials

(a) Reinforcement concrete for headers and stretchers shall comply with the requirements of Section 2000.

(b) Timber for headers and stretchers shall comply with the requirements of IS: 883. they shall be treated or untreated, sawn or log as shown on the Drawing or described in the contract and comply with the requirements of Sub-clause 2302 (1).

(c) Drift pins shall be steel bars of a diameter as shown on the Drawing and shall comply with the requirements of IS: 1786:-1985. The length of drift pin shall be equivalent to the combined thickness of three times the depth of one member plus 100 mm.

(d) Steel crib wall components shall be of the thickness, shape and dimension as shown on the Drawing and shall comply with the requirements of IS: 2062-1992. All bolts shall also be of mild steel and shall conform to IS: 2062-1992, but have a minimum tensile

strength of 485 N/sq.mm. and a minimum percentage elongation of 14. All steel components, bolts, base plates, splice plates shall be galvanized or painted as shown on the Drawing or described in the contract. Such protection shall comply with Clause 2209.

(e) Backfill material shall be of such character that it will not sift or flow through the openings in the wall, shall be free from clay and other deleterious fines, and shall conform to the requirements set out in Table 24.4

Table 24.4: Grading and Compaction Requirement of Backfill Material

Combined height of wall and surcharge (vertical from heel of wall to top of Surcharge)	Sieve size (mm)	Percentage passing by weight	Compaction requirement
0 to 3 m	75	100	Min. 93% of MDD in accordance with IS: 2720 Part 8
3 to 8 m	175 4.75	100 35 – 100	- do -
Over 8 m	75 4.75 0.300 0.075	100 25 – 70 5 – 20 0 - 5	- do -

(3) Construction

(a) Reinforcement Concrete Crib Walls

Walls founded on embankment material shall have a minimum depth of 1.5 m below the base of the wall which is compacted to a minimum of 93% of MDD (IS 2720, Part 8). Where the foundation pressure exceeds 0.27 N/sq.mm. the embankment material shall comply with the grading in Table 24.4 compacted to 935 (minimum) of MDD. When walls are founded on original ground it shall have a bearing value adequate to withstand the foundation pressure of the wall but shall not be less than 0.2 N/sq.mm. If the original ground is unsuitable, it shall be removed and replaced to a sufficient depth as approved by the Engineer, by material complying with the grading requirements of Table 24.4 compacted to 93% (minimum) of MDD. The foundation stretchers shall be laid true to line, level and slope on a 100 mm thick loose layer of material complying with Table 24.4. The laying of headers, stretches and blocking pieces shall then proceed. Backfillings

to the crib wall shall be carried out in lifts not exceeding 150 mm and compacted to the compaction indicated in Table 24.4. The gap between bearing where the gap is between 1.5 mm and 3 mm asbestos sheet packing complying with walls whose height exceeds 10m, asbestos sheet packing shall be placed between all bearing surfaces below the 10m level.

(b) Timber Crib Walls

The requirements in respect of the depths and bearing values of the ground on which the wall is to be founded shall be as for reinforced concrete crib walls. The foundation stretchers shall be laid true to line, level and slope on a 100 mm thick loose layer of material complying with Table 24.4. Headers and stretchers shall be secured with drift pins as shown on the Drawing with a minimum of 4 per joint. Holes for drift pins shall be bored with a bit of the same size as the pin. All holes that are bored in treated timber shall be swabbed with two coats of creosote. Back filling shall not commence until all drift pins for the portion of crib to be filled have been driven. Backfill material shall be placed in lifts not exceeding 150 mm and compacted to a minimum of 93% of MDD. Where unsawn timber is used in crib walls the bearing areas shall be wroth square so that there is true and complete bearing between the elements of at least 400 sq.cm.

(c) Steel Crib Walls.

The requirement for bearing values of supporting ground shall be as for reinforced concrte crib walls. The base plates shall be laid true to the line, level and slope on a 200 mm thick loose layer of material complying with Table 24.4. Backfilling shall be as for reinforced concrete walls.

(4) Tests and Standards of Acceptance

The materials shall be tested in accordance with the relevant standards specified and shall meet the prescribed criteria. The Contractor shall furnish necessary test certificates as required by the Engineer.

The work shall conform to these Specifications and shall be to the true lines, levels and dimensions as indicated on the Drawing with no bulges or sags. The lines of stretchers and headers shall have a uniform appearance.

Frequency of testing for concrete shall be as specified in Section 2000. Backfill material shall be tested for gradation for each change in source of material, subject to a minimum of one test for every 250 m3 of material or part thereof. Minimum three of in-situ density shall be carried out in each layer of backfill. All the test results shall meet the specified criteria.

(5) Measurement

Crib walls shall be measured in running meter for each type of headers and stretchers placed in their final position and accepted.

Excavation and backfilling shall be measured separately as provided in the respective Sections of these Specifications.

(6) Payment

Each type of headers and stretchers measured as provided above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as set out in Clause 112 to complete the work as per these Specifications.

Excavation and backfilling shall be paid separately as provided in respective sections of these Specifications.

2403. SLOPE STABILISATION AND SURFACE EROSION PROJECTION

(1) Scope

This Clause covers the works related to the furnishing of materials and construction of slope stabilizing measure in dry stone pitching, grouted stone pitching, gabion, masonry walling rock dowels and rock anchors/bolts and wire netting on slopes as shown on the Drawing or as instructed by the Engineer.

(2) Excavation of Soil and Rock

Excavation of soil for landside stablisation and slope protection shall include excavation and removal of existing landslide debris, streambed debris, the trimming of scarp faces and gully sides and excavation required to construct gabion and masonry walls or other structures, in accordance with the lines, levels, grades and dimension as shown on the Drawing or as directed by the Engineer. Excavation may be undertaken either by machine or by labour or in combination of the both. However, during any excavation work care must be taken to ensure that the excavation does not endanger the stability of adjacent slopes. In some locations the Engineer may direct the Contractor to use labour only during excavation, or issue other directions as to the method of excavation.

The cutting of tracks to enable machines to reach otherwise inaccessible areas shall not be allowed during slope stablisation work. However, access tracks may be constructed only with the specific approval of the Engineer where no benching into the hillside is necessary.

Excavation and removal of rock for landslide stablisation and slope protection shall include removal of individual rock blocks form a rock face, removal of potentially unstable rock masses or isolated individual boulders. Excavation and removal of rock may be undertaken by pneumatic tools, hand tools or other approved methods.

The slopes of cuttings shall be shaped or terraced in accordance with the Drawing and as required by the Engineer.

(3) Fill Areas

During slope stabilization work, small areas of fill may be required, such as to infill gullies. Fill material for such purpose shall consist of suitable material as defined in Clause 902 and shall be deposited and compacted by approved plant as defined in Clause 910, in accordance with the lines, levels and grades shown on the Drawing and as directed by the Engineer.

(4) Dry Stone Pitching

(a) Materials

Stone used for pitching shall be from a quarry or arising from the excavation and be angular in shape. If river boulders are used they shall be broken into angular pieces. The stone shall be sound, hand, free from cracks or other defects. Not less than 80% of the stones, except those used for chinking shall have individual volumes of not less than .01 cubic metres. Waste concrete may be used provided it is sound and meets the size requirements of the stone. The stones, when immersed in water for 24 hours, shall not absorb water by more than 5 percent of their dry weight when tested in accordance with IS: 1134.

(b) Construction

Construction shall comply with Sub-clause 2406 (5).

(c) Tests and Standard of Acceptance

Tests and standard of acceptance shall comply with Sub-clause 2046 (5) except the size of the stone which shall comply as per Sub-clause 2043 (4) (a).

(5) Grouted Stone Pitching

(a) Materials

Stone shall comply with the requirements specified in Sub-clause 2403 (4). Grout shall consist of 1 parts of cement and 3 parts of sand measured volumetrically and mixed with sufficient water to produce

the required consistency as instructed by the Engineer. Mortar and sand shall comply with the requirements specified in Clause 2502.

(b) Construction

Method of laying and thickness shall be as for dry stone pitching specified in Sub-clause 2406 (5). After the stones have been laid on the entire slope, all spaces between them shall be filled with clean rock fragments, crushed rock or gravel. More than 15% of the fill materials shall not pass 20 mm sieve. The material shall be carefully hand tamped into place.

Prior to the application of grout the surfaces of the stone shall be thoroughly cleaned of adhering dust and then moistened. The interstices between the stones shall be completely filled with grout throughout the entire thickness of the stone pitching. Grouting operations shall progress from the bottom of the slope toward the top. Grout shall be placed in a continuous operations for any day's run at any location.

After the grout has been placed, the stone shall be thoroughly brushed so that their top surfaces are exposed. The grouted pitching shall be cured for a period of not less than four days, after grouting. Curing shall be done with wet sacking or other approved cover, and shall not be subjected to loading until adequate strength has developed. Where required, or instructed by the Engineer, weep holes shall be provided in the pitching.

(c) Tests and Standard of Acceptance

Stone shall be tested in accordance with these Specifications and shall meet the prescribed criteria. One set of test (3 tests in a set) shall be carried out for every change in source of materials.

The finished surface of the grouted pitching shall present an even, tight and neat appearance with no stones surface varying by more than 25 mm from the specified surface grades and lines. The average thickness of the pitching, measured at right angles to the surface, shall not be less than the specified average thickness.

(6) Gabion Wire Mattress

The materials used shall comply with Clause 2401. The mattress shall be assembled and filled in the same manner as for gabions specified in Clause 2401. Ties and anchorages shall be provided as shown on theDrawing.

(7) Wire Netting

Where required by the Engineer or shown on the Drawing, slopes shall be covered with wire mesh to prevent small scale raveling and erosion. The wire mesh shall confirm to the requirements specified in Clause 2401 and shall have a minimum thickness of SWG 10. Wire netting shall be constructed in accordance with Sub-clause 2809 (4).

(8) Masonry/Concrete/Reinforced Concrete walling

Walls of the specified type (s) shall be constructed in accordance with the Drawing and as directed by the Engineer to act as retaining structures, as revetment structures or as buttresses.

Materials for masonry walling shall comply with Clause 2602, and construction with Clause 2603. Mortared masonry shall be coursed and comply with Clause 2607. Dry masonry shall comply with Clause 2608. Composite masonry shall comply with Clause 2609.

Materials for concrete/reinforced concrete walling shall comply with Section 2000.

In areas where buttresses are to be constructed, the rockface to supported shall be thoroughly cleared of all vegetation, and loose or spalling rock fragments prior to construction of the buttress.

(9) Rock Dowels

(a) Materials

Rock dowels shall consist of deformed high tensile steel bars complying with IS 1786. unless otherwise specified, the dowel bars shall be not less than 20 mm in diameter and shall be of 1 m in length.

Grout shall consist of either cement slurry or cement-sand mortar or concrete as shown on the Drawing or as instructed by the Engineer. Water cement ratio shall not exceed 0.45. The grout cover to the dowel shall be at least 6 mm.

Cement, sand, aggregates and water shall comply with the requirements specified in Section 2000.

(b) Construction

The location, direction and length of each hole for rock dowels shall be approved by the Engineer. After drilling a hole, the Contractor shall clear the hole of all drill cuttings, sludge and debris and shall seal the hole to prevent ingress of foreign matter. Before the rock dowels

are installed, the position, inclination, bearing, length and diameter of the drill holes shall be approved by the Engineer.

The drill hole shall be thoroughly flushed with clean water immediately before installation of the rock dowel. Grouting procedure for rock dowels shall be as directed by the Engineer.

The free end of the dowel bar shall be securely bolted with steel bearing plate and then covered with concrete capping of grade M30/20 to prevent corrosion.

(c) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificate for each lot of dowel bars. The test certificate results shall meet the specified criteria. The Engineer may ask for testing the bars in independent laboratories and the test result shall meet the specified requirements.

Six sets of test cubes of grout shall be taken from at least one representative batch of grout each day the grouting is carried out and the results shall meet the requirements shown on the Drawing. Unless otherwise shown on the Drawing, the minimum compressive strength of test cubes shall be as follows:

7 days	-	18 N/mm^2
28 days	-	30 N/mm^2

(10) Rock/Earth Anchors

(a) Materials

Rock/earth anchor shall be non-prestressed or partly prestressed and of quality shown in the Drawing or specified elsewhere in the contract. The prestressing load shall be as specified on the Drawing. Unless otherwise on the Drawing or specified in the contract, the anchor bar shall have a diameter of 25 mm. End plates, couplings, nuts, washers and centralizers shall be of the quality shown on the Drawing.

Grout shall be cement slurry. Cement and water used shall meet the requirements specified in Section 2000. The water cement ration shall be between 0.30 and 0.45 or as instructed by the Engineer.

(b) Construction

The anchor direction both in plan and zenith shall be more or less perpendicular to the weakened plane as indicate on the Drawing or directed by the Engineer. However, for the case of gravity grouting, the zenith inclination of anchor bars shall be kept minimum 15o below the horizontal. Unless others wise shown on the Drawing or specified

in the Contract, the bore hole shall have 90 mm diameter. Log shall be prepared for each bore hole. Placing and grouting of anchors shall commence only after the approval from Engineer.

The bond length of anchor bars shall, in no case, be less than 5 m and the tendon length shall depend upon the thickness of loose and soft layer above, as investigated by the Engineer during construction. The free anchor length (where no grouting is executed) shall be fully corrosion protected with approved insulating wrapping or polythene or other materials.

Approved commercial grade extra fine aluminium power in an amount not exceeding 0.005% by mass of cement or an approved admixture may be blended with the cement to ensure necessary expansion of the grout.

Before grouting, the bore hole shall be flushed clean and free of any loose and clayey materials. Prior to grouting, the mixture shall be mixed at least for 3 minutes. The grout shall be used as soon as possible after mixing the ingredients but in any event within the initial setting time of the cement.

Grouting shall be done by pump or gravity flow. Grout shall be forced into the bore hole continuously to completely fill up the bore hole to the anchor head. The injector pipe shall be taken out during and immediately after grouting. The pointer shall always be intruded into the grouting mass. The amount of grout mix used shall be recorded additional grouting shall be done to ensure filling of all voids.

Prior to establishing anchors, test anchor shall be made in equivalent/similar soil/rock conditions through which the anchors are to be placed with the length similar to the anchors intended to be executed. Test anchor shall be loaded by hydraulic device. Loading shall be as directed by the Engineer. If the anchor fails at a lower force, another test anchor shall be established and the bonding length increased as instructed by the Engineer.

Depending upon the type of rock soil formation and depth of sound rock strata, the fixed anchor and tendon lengths are subject to vary, so that a minimum anchor design load (anchor testing) can be obtained. The final decision for the change in anchor lengths lies fully on the rock investigation, and judgment by the during construction and the result of anchor tests. In severely jointed or fractured rock water permeability test as directed by the Engineer shall be conducted prior to grouting.

The free end of the anchors shall be fixed with anchor head. The face of anchor head shall be inclined with vertical to the same angle as the anchor bar with the horizontal so that the load transfer to the anchor

strip shall be axial. The anchor bar at the anchor head should be filled to tolerance of $\pm$ 5 mm concentrically with the tendon, which in turn, should not suffer an angular deviation in excess of $\pm$ 3^o from the axial position.

(c) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificate for each lot of anchor bars. The test certificate results shall meet the specified criteria. The Engineer may ask for testing the bars in independent laboratories and the test results shall meet the specified requirements.

Six sets of test cubes of grout shall be taken from at least one representative batch of grout each day the grouting is carried out and the results shall meet the requirements shown on the Drawing. Unless otherwise shown on the Drawing. The minimum compressive strength of test cubes shall be as follow:

7 days	-	18 N/mm^2
28 days	-	30 N/mm^2

Ten percent of the anchors shall be tested in the field to the specified design load. The sequence of testing shall be decided by the Engineer. The test shall meet the specified criteria.

(11) Rock Bolts

(a) Materials

Rock bolts shall be such that it is capable of permanently sustaining the specified working load as shown on the Drawing.

Grout shall be cement slurry mix. The grout shall have a water/cement ratio not exceeding 0.45. The use of admixtures shall be subjected to the Engineer's approval. Cement and water shall meet the requirements specified in Section 2000.

(b) Construction

Method of installation, on rock bolt system, full detail of rock bolt, bearing plate, washer and nut, fixed length, grease and sheathing, bearing rod construction, material and curing period, grout of resin details including additives, bleed pipes, stressing and capping details shall be as specified in the design Drawing or as instructed by the Engineer.

The holes for the bolts shall be drilled to the line to the required depth for any particular bolt. The depth of the hole shall be such that the installed bolt is located 150 mm from the extremity of the hole. The

diameter of the drill hole shall be sufficient to ensure a miniumum 10 mm annulus of grout or resin and also permit free entry of the bolt together with any required protection. Immediately prior to insertion of the rockbolt, the hole shall be cleaned and blown free of dust. In the event of the drilling encountering any material other than solid rock, this shall be recorded and reported to the Engineer without delay.

A detailed record of the grouting of each drill hole including the date performed and the identification marks of associated test cubes shall be maintained.

(c) Tests and Standard of Acceptance

Copies of the manufacturer's test certificate for each steel bolts to be supplied shall be furnished by the Contractor. The test results shown in the certificate shall meet the specified criteria. In addition, the Engineer may ask for testing in independent laboratories. All test results shall meet the specified requirements.

Six sets of test cubes of grout shall be taken from at least one representative batch of grout each day the grouting is carried out and the results shall meet the requirements specified in Sub-clause 2403.

(12) Measurement

(a) Excavation for structures, common backfill/previous backfill/filter materials, gabion mattresses, masonry/concrete/reinforced walling and wire netting shall be measured as provided under respective Sections of these Specifications.

(b) Dry Stone Pitching and grouted stone pitching shall be measured in square meters.

(c) Rock dowels and rock/earth anchors shall be measured in running meter placed inside the ground and accepted. The exposed dowels/anchors, steel bearing plates, bolts, anchor heads and other accessories, if any, shall not be measured separately.

(d) Rock bolts shall be measured in numbers as placed and accepted. Bearing plates, washers, nuts, and other accessories shall not be measured separately.

(13) Payment

(a) The quantity of excavation for structures, common backfill/previous backfill/filter materials, gabion mattresses, masonry/concrete/ reinforced concrete walling and wire netting shall be paid as provided under respective Clauses of these Specifications.

(b) The quantities of dry stone pitching, grouted stone pitching, rock dowels, rock/earth anchors and rock bolts shall be paid as per the respective contract unit rates. The contract unit rate shall be the full and the final payment to the Contractor as per Clause 112 to complete the works as per these Specifications.

2404. SUB-SURFACE DRAINS

(1) Scope

This Clause shall cover the works related to the construction of sub-surface drainage networks in slopes, slides and under road pavement. The drains shall be either main or tributary or of other types as shown on the Drawing.

Sub-surface drains shall consist of perforated HOP pipes surrounded by granular material laid in a trench. If specified in the contract, sub-surface drains shall also consist of perforated HOP pipes surrounded by geotextile/geomembrane and granular material laid in a trench.

(2) Materials

The materials used for construction of sub-surface drains shall comply with following requirements:

(a) Stone

Stones used for filling and lining of sub-surface drains shall comply with the specifications for dry stone pitching given in Sub-clause 2403 (4).

(b) Cement

Cement shall be Ordinary Portland Cement complying with the requirements of Section 2000.

(c) Mortar

The mortar used for cement masonry lining shall be as specified in Sub-clause 2403 (5).

(d) Gabion Works

Gabion works shall comply with the requirements specified in Clause 2401.

(e) Filter Material

Filter materials used in drains shall comply with the requirements specified in Clause 3110.

(f) Geomembrance

Geomembrane shall be made of PVC or polythene sheets of at least 0.8 mm thickness, duly protected from ultra-voilet exposure with 2.5 per cent carbon black, in black colour, supplied in roll form with a minimum of 3 m width. The joints of these sheets shall be heatbonded or seamed for effective permeation cut off. While fixing on to a slope, they shall not be punctured or stappled to impair their use.

(g) Geotextile

Geotextiles used for lining of drain trenches shall be as per the requirements of Section 600. The type of geotextile to be used for drains shall be approved by the Engineer prior to starting the works.

(h) Drain Pipe

Drain pipes shall be made of high density polyethylene and shall comply with series II as specified by NS 40/2040. Jointing of pipes shall be done by fine-cutting and heating following with an equipment complying with the prescription of the HDP pipe manufacturer. Pipes may be jointed with angles to fit the requirements of the terrain, but angles shall not exceed the maximum specified by the manufacturer. The joints shall be watertight and develop the same strength as unjointed HDP material. The method of jointing shall be approved by the Engineer prior to starting the works. Drain pipes shall be provided with holes of minimum 5 mm diameter. The pipes shall be perforated by drilling minimum 50 holes per meter length on the upper half of the pipe in a staggered pattern uniformly distributed. The Engineer might adjust these specifications according to the site conditions.

(3) Construction

The detailed layout of the drainage network shall be as instructed by the Engineer, based on the general layout given in the Drawing.

The work shall start with construction at road side and then go up the slope by using already constructed drains as buttress for new drains.

The main drains shall be placed in naturally existing depressions. The tributary drains shall be at a maximum inclination of 45° to the main drain.

(a) Sub-Surface Drains without Geotextile/Geomembrane

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown on the Drawing. Following considerations shall be made while excavating the drain and dumping excess materials.

(i) Depth of excavation shall be according to Drawing.

(ii) Top of structure shall be lower than natural ground.

(iii) No blasting shall be done in slides.

Wherever required or instructed by the Engineer, the Contractor shall provide trench struts and shoring as per approved design and shall execute in a manner to resist the earth pressure and in order to protect labour and work.

Where unsuitable material is encountered at the bed of trench, the same shall be removed to such depth as instructed by the Engineer and backfilled with approved material shall be compacted as specified in Clause 910.

Laying of pipe in the trench shall be started at the outlet end and proceed towards the upper end, true to the lines and grades specified. Before placing the pipe, filter material shall be laid for the full width of the trench bed and compacted. Unless otherwise shown on the Drawing, the thickness of this layer shall be 150 mm.

After the pipe installation has been completed and approved filter material shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm 2405 I and thoroughly compacted to 93% of the MOD (heavy compaction).

Pitching shall be done as per Clause 2403. The finished slope shall be reshaped to facilitate proper surface drainage towards drains

(b) Sub-surface Drains with Geotextile/Geomembrane

Excavation and backfilling shall be carried in the same manner as described above in (a). After excavating the trench for sub-surface drain, the filter fabric shall be placed and then the pipe shall be installed in the position as shown on the Drawing. Surfaces receiving filter fabric shall be free of loose or extraneous material and sharp objects. Adjacent rolls of the fabric shall be overlapped to a minimum width 450 mm. The preceding roll shall overlap the following roll in the direction the material is being spread.

After the installation of pipe, the trench shall be backfilled with the filter material in the same manner as described above in (a)

(4) Tests and Standard of Acceptance

Copies of the manufacturer's certificates for geotextile/geomembrane and drain pipe to be used while shall be furnished by the Contractor. In addition, the Engineer may ask for testing in independent laboratories. All test results shall meet the specified requirements.

Minimum one set of test for gradation analysis and compaction of filter material shall be checked for every 50 cu.m. and/or every change in source of material. The results shall meet specified requirements

(5) Measurement

Sub-surface drain with/without geotextile/geomembrane shall be measured in running meter which shall be inclusive of earth excavation, backfill/filter, geotextile/geomembrane. Drain pipe shall be measured in running meters separately.

Pitching shall be measure as provided under respective clauses of these Specifications.

(6) Payment

Sub-surface drains with/without geotextiles/geomembranes, drain pipe and pitching shall be paid at the respective contract unit rates. The contract unit rates shall be the full and the final compensation to the Contractor as per Clause 112 to complete the works as per these Specifications.

2405. DRILLED SUB-SURFACE DRAINS

(1) Scope

This Clause covers the works related to the construction of drilled sub-surface drains in slopes and slides. The drilled sub-surface drains shall consist of HDP drainpipes covered by geotextile and placed into drilled holes

(2) Material

Geotextile used in drilled sub-surface drains shall meet the requirements specified in the Contract or shown on the Drawing.

Drain pipes shall comply with the requirements specified for Series II high density polythene pipes in accordance with NS 40/2040. Unless otherwise shown on the Drawing, the pipe shall have a diameter of minimum 40-mm. The pipes shall be perforated by drilling minimum 50 holes per meter length on the upper half of the pipe in a staggered pattern uniformly distributed with a diameter of 3 mm (minimum) to 6mm (maximum).

(3) Construction

Drilling of borehole, minimum diameter 73mm shall be carried out by the Contractor as shown on Drawing. The drill hole slope shall be 30 to 70 upward or as directed by the Engineer. The drain pipes shall be covered by a geotextile.

The length of drains shall be decided by the Engineer based on hydro-geologist conditions encountered.

The pipes shall be secured rigidly in the drill hole outlet.

(4) Tests and Standard of Acceptance

The Contractor shall submit a sample of geotextile and HDP pipe along with factory certificate for the approval of the Engineer. It shall be ensured that the geotextile and the pipe meet the specified criteria.

(5) Measurement

Drilled subsurface drains shall be measured in running meter. No separate measurement shall be done for geotextile.

(6) Payment

The quantity of drilled sub-surface drains measured as provided above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the works as per these Specifications.

2406. SCOUR PROJECTION AND RIVER TRAINING WORKS

(1) Scope

This Section covers the works related to the construction of scour protection and river training works. These works shall include all operations necessary for construction of appropriate structures adjacent to culverts, piers and abutments, at outfalls of drainage, along the road side and elsewhere, where protection is required for ensuring safety of structures against damage by flood/flow of water.

(2) Materials

Stones/rocks used in this section of the specifications shall be hard, dense, unlaminated natural stone, not liable to deterioration in water and of general quality of soundness and abrasion resistance prescribed for concrete aggregates. Broken rocks shall be of regular "cubical" shape and shall not be flaky. Flat or needle shaped rocks shall not be accepted unless the

thickness of the individual piece exceeds 1/3 of their length. The specific gravity of the stone/rock shall be not less than 2.50 and when immersed in water for 24 hours, it shall not absorb water more than 5 percent of its dry weight tested in accordance with IS: 1124. Unless otherwise specified the minimum size/weight of the stone/rock shall be as specified below:

For Rip Rap in river-bed and foundation protection:-

At least two thirds of the total weights of the stone/rock used shall be heavier than 75 kg.

For Plum Concrete:-

The size of the stone/rock shall not be larger than 200 mm measured in any direction.

Concrete to be used in plum concrete shall be as specified in Section 2000.

For Dry Stone Pitching/Revetment on Slopes:-

The size and weight of individual stone shall conform to Clause 5.5.5.1 of IRC: 89. However in no case weight shall be less than 40 kg except for spalls. The total volume of spalls as per including voids shall not be more than twenty percent of the total volume of the pitching.

For use in Gabions:-

As per Clause 2401.

G.I. wire to be used in gabions shall comply with Clause 2401 and the filter shall comply with Clause 3110.

All materials to be used shall be subject to the approval of the Engineer.

(3) Rip Rap

(a) Construction

The surface where rip rap to be executed shall be made to the line and level as indicated in the drawing or directed by the Engineer. To achieve this necessary excavation, filling with compaction and/or levelling shall be done as per site condition. On the prepared surface stone/rocks shall be placed individually to provide minimum space among the stones. Needle like shapes and protrusions on the surfaces of stones shall be chipped off by hammer so that stones are beded properly and voids are reduced. To avoid sliding of stones/rocks downwards, the placing of stones shall be started from the lower edge to proceed towards upper edge. By driving small stones or spalls into interstices, laid stones shall be tightly wedged so that individual stone

shall not be removed easily. The top surface, the lines, levels and depth of rip rap and grade shall be as indicated on the drawing or directed by the Engineer.

(b) Tests and Standards of Acceptance

Stone shall be tested for water absorption and specific gravity. The test results shall meet the specified criteria. At lease 3 set of tests shall be made for every source of material. About one sq.m (1 M x 1 M) of the completed rip rap in every 200 sq.m or in pan thereof, shall be dismantled. The aggregate weight of all stones obtained from dismantling shall be computed upto full depth. Then aggregate weight of individual boulders weighting more than 75 kg shall be obtained. The result shall meet the specified requirement.

The dismantled portions shall be made good after completion of the test.

(4) Plum Concrete

(a) Construction

Composition of the plumb concrete shall be 60 to 70 % M 15/40 concrete and 40 to 30 % of stones by volume or as directed by Engineer. The place to be filled up with the plum concrete shall be cleaned and chipped for adhesion with the concrete. Following completion of form work a layer of concrete minimum 100mm thick shall be laid upon which clean and moist stones shall be placed at a distance of min 100mm measured from face to face in any direction. The distance between the outer edge of the concrete mass and the nearest face of the stone to the edge shall not be less than 100 mm.

Then another layer of concrete having thickness not less than 100mm measured from the top of the stone to the top surface of the layer shall be laid and compacted.

In case the proportion of concrete to stones is to be changed, the clear space between stones shall be adjusted as directed by the Engineer.

After compaction, again stones shall be placed on the layer as described above and the process shall be continued until the top layer of the concrete is completed. The placing of stones shall be staggered both in horizontal and vertical directions

(b) Tests and Standard of Acceptance

Stones shall be tested for specific gravity and water absorption test. The test result shall meet the requirements as specified in these Specifications.

Concrete shall be tested as specified in section 2000

(5) Ptiching/Revetment on Slopes

(a) Dry Stone Pitching

(i) Construction Operations

The pitching shall be provided as indicated on the drawings. The thickness and the shape of stone pitching shall be as shown on the Drawing.

Before laying the pitching, the sides of banks or surface of the slope shall be trimmed to the required slope and profiles and shall be put up by means of line and pegs at Intervals of 3 metres to ensure regular straight work and a uniform slope throughout. Depressions shall be filled and thoroughly compacted.

Where required the filter/granular material shall be laid over the prepared surface starting from bottom and compacted to the thickness specified on the drawing. If not specified, the minimum compaction to be achieved shall be 93% of the MDD (heavy compaction).

The lowest course of pitching shall be started from the toe wall and built up in courses upwards.

Stone shall be placed to the required length, thickness and depth conforming aid upon to the Drawing. Stones shall be set normal to the slope, and placed so that the 1easured largest dimension is perpendicular to the face of the slope, unless such concrete dimension is greater than the specified thickness of pitching. The pattern of 100 mm. laying shall be such that the joints are broken. Wherever necessary spalls shall be used for tight packing and reduction of voids which shall not exceed fifteen percent of the total volume of pitching. The top surface of the pitching shall be smooth.

When full depth of pitching can be formed with a single stone, the stones shall be laid breaking joints and all interstices shall be filled in with spalls of the proper size and wedged in with hammers to ensure tight packing.

When two or more layers of stones must be laid to obtain the design thickness of pitching, construction method of dry masonry shall be used and stones shall be well bonded. To ensure regular and orderly disposition of the full intended quantity of stone as shown, template cross walls in dry masonry shall be built about a metre wide and to the full height of the specified thickness at suitable intervals and all along the length and width of the pitching. The stones shall be packed as specified within these walls.

(ii) Tests and Standard of Acceptance

Stones shall be tested for water absorption and specific gravity and shall meet the specified criteria. One set of test (3 tests in a set) shall be carried out for every change in source of material and shall meet the specified criteria.

About one sq.m (1 m x 1 m) of the completed stone pitching in every 200 sq.m or in part of it shall be dismantled upto complete depth. The aggregate volume of the spalls (stones weighing less than 40 kg) and the aggregate volume of the stones weighing more than or equal to 40 kg shall be obtained. Thus the percentage of total volume of the spalls and voids shall be determined. The test result shall meet the specified requirement.

The dismantled portion shall be made good by the Contractor at his own cost after completion of the test.

The finished surface of pitching shall present an even, tight and appearance with no stones varying by more than 25mm from the surface lines and levels. The thickness of pitching, measured at right angle to the surface, shall not be less than the specified thickness

(b) Grouted Stone Pitching

Grouted stone pitching shall comply with Sub-clause 2403 (5) and shall be measured as per Sub-clause 2403 (12) and shall be paid Sub-clause 2403 (13).

(c) Gabion Pitching

(i) Construction

The surface on which the gabions are to be laid shall be trimmed to true lines level and grade as described above in Sub-clause 2406 (5) (a). On the prepared surface, gabions shall be laid as specified in Clause 2401.

(ii) Tests and Standard of Acceptance

The Contractor shall produce manufacturers test certificate of the gabion wires which he proposes to use. Gabion wires shall be tested as per Clause 2401. The test result shall meet the requirement.

Tests and standard of acceptance for this Clause shall be as per Sub-clause 2401 (4).

The size, slope of the completed gabions and wire mesh shall meet the specified requirements when measured:

The tolerance applicable to this measurement shall be as given in Sub-clause 2401 (3) (g).

(6) Measurement

(a) Levelling, Filling with Compaction, Trimming and/or Earth Excavation.

Levelling, filling with compaction, trimming requiring earth excavation or filling not exceeding 150mm in depth shall be measured in sq.m, whereas excavation or filling exceeding 150mm in depth shall be measured in cu.m. Both type of measurements shall not be allowed at the same place. For computation of quantities initial and final ground levels not exceeding at 5 M in both directions in plan and plan of the area to be covered shall be recorded by joint survey i.e. by the contractor and the engineer jointly. Quantities shall be computed based on these levels using standard methods of measurement. Levelling, filling trimming and/or earth excavation other than indicated on the Drawing or instructed by the Engineer shall not be measured.

(b) Rip Rap:-

Rip Rap shall be measured in sq.m.

(c) Plum Concrete

Plum Concrete shall be measured in cu.m. Form work shall be measured in sq.m separately. Struts, bracing supports etc. shall not be measured separately. They are deemed included in the measurement of form work.

(d) Dry Stone Pitching/Revetment on Slopes

Dry stone pitching shall be measured in sq.m.

G.I. wire mesh provided for gabion boxes and mattresses shall be measured in sq.m. Binding wires, selvedge wire and other accessories shall not be measured separately. They are deemed included in the measurement of the G.I. wire mesh.

Stone filling in gabions including fixing the gabions in position, tying with binding wires and tension wires as specified shall be measured in cu.m.

(7) Payment

Levelling, filling with compaction, trimming and/or earth excavation, rip-rap, plum concrete, from work, dry stone pitching, gabion boxes, gabion mattress, stone filling shall be paid as per contract unit rate of the respective item which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the works as per these Specifications.

SECTION 2500 – BRICKWORKS FOR STRUCTURES

SECTION 2500 –BRICKWORKS FOR STRUCTURES

2501. SCOPE

This Section covers the furnishing of materials and construction of brick works for structures in accordance with the detail shown on the Drawing and these Specifications or as directed by the Engineer.

2502. MATERIALS

(1) Bricks

Burnt clay bricks shall conform to the requirements of NS-1/2035 except that minimum compressive strength when tested flat shall not be less than 8 N/mm^2 for individual bricks and 10 N/mm^2 for average 5 specimens and that the size may be according to local practice with a tolerance of $\pm$ 5 percent.

(2) Mortar

Mortar shall comply with IS 2250-1981; Code of Practice for preparation and use of masonry mortar. The mortar used in work shall have the strength not less than 5 N/mm^2 or 7.5 N/mm^2 at 28 days as specified.

However, if provided in the Contract, cement and sand may also be mixed in specified proportions. Cement shall be proportioned only by weight, by taking its unit weight as 1.44 tonne per cubic metre and sand shall be proportioned by volume after making due allowance for bulking.

Sand shall comply with Clause 613. Cement shall comply with Clause 614.

The mixing shall be done in a mechanical mixer unless hand-mixing is permitted by the Engineer. If hand-mixing is allowed, the operation shall be carried out on a clear watertight platform. In the required proportion cement and sand shall be first mixed dry to obtain an uniform colour. Then required quantity of water shall be added and the mortar shall be mixed to produce workable consistency. The mortar shall be mixed for at least three minutes after addition of water in the case of mechanical mixing. In the case of hand mixing, the mortal shall be hoed back and forth for about 10 minutes after addition of water in order to obtain uniform consistency.

Only that quantity of mortar shall be mixed at a time which can be used completely before it becomes unworkable. Any mortar that has become unworkable due to loss of water before elapsing the initial setting time of cement, shall be rewet to make it workable and shall be used in the works. On no account mortar shall be used after elapsing the initial setting time of cement.

2503. SOAKING OF BRICKS

Bricks shall be soaked in water for a minimum period of one hour before use. When bricks are soaked they shall be removed from the tank sufficiently in advance so that at the time of laying they are skin dry. Such soaked bricks shall be stacked on a clean place where they are not spoilt by dirt, earth, etc.

2504. LAYING OF BRICKS

All bricks work shall be laid in English bond, even and true to line, plumb, level and all joints accurately kept. Whole bricks used on the face shall be selected ones of uniform size and true rectangular face.

Bricks shall be laid with frogs up, if any, on a full bed of mortar. When laying, bricks shall be slightly pressed so that the mortar gets into all the surface pores of bricks to ensure proper adhesion. All joints shall be properly flushed and packed with mortar so that no hollow spaces are left.

Before laying bricks in foundation, a layer of not less than 12 mm of mortar shall be spread to make the surface on which the brick work will be laid even. Immediately thereafter, the first course of bricks shall be laid.

The brick work shall be built in uniform layers. Corners and other advanced work shall be raked back. Brick work shall be done true to plumb or in specified batter. No part of it, during construction, shall rise more than one metre above the general construction level, to avoid unequal settlement and improper jointing.

Toothing may be done where future extension is contemplated but shall be used as an alternative to raking back.

2505. JOINTS

The thickness of joints shall not exceed 10 mm.

2506. JOINTING WITH EXISTING STRUCTURES

When fresh masonry is to be placed against existing surface of structures, the surface shall be cleaned of all loose materials, roughened and wetted as directed by the Engineer so as to effect a good bond with the new work.

2507. CURING

Green work shall be protected from rain by suitable covering. Masonry work in cement mortar shall be kept constantly moist on all faces for a minimum period of

seven days. The top of the masonry work shall be left flooded with water so as not to disturb or washout the green mortar.

During hot weather, all finished or partly completed work shall be covered or wetted in such a manner as to prevent rapid drying of the brick work.

2508. SCAFFOLDING

The scaffolding shall be sound and strong to withstand all loads likely to come upon it. The holes which provide resting space for horizontal members shall not be left in masonry under one metre in width or immediately near the skew backs of arches. The holes left in the masonry work for supporting the scaffolding shall be filled and made good.

2509. CONDITION OF EQUIPMENT

All equipment used for mixing or transporting mortar and bricks shall be clean and free from set mortar, dirt or other injurious foreign substances.

2510. FINISHING OF SURFACES

(1) General

The surfaces can be finished by 'jointing', 'pointing' or 'plastering', as specified. For a surface which is to be subsequently plastered or pointed, the joints shall be squarely raked out to a depth, of 15 mm while the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed with water, cleaned and wetted.

The mortar for finishing shall be prepared as per Clause 2502.

(2) Jointing

In jointing, the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick-work. The faces of brick-work shall be cleaned to remove any splashes of mortar during the course of raising the brick-work.

(3) Pointing

For pointing, the mortar shall be filled and pressed into the raked out joints, before giving the required finish. The pointing shall then be finished to proper type given on the Drawing. If type of pointing is not mentioned on the Drawing the same shall be ruled pointing. For ruled pointing after the mortar has been filled and pressed into the joints and finished off level with

the edges of the bricks, it shall while still green be ruled along the centre with a half round tool of such width as work shall may be specified by the Engineer. The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned of all mortar

(4) Plastering

Plastering shall be started from top and worked down. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. Wooden screeds 75 mm wide and of the thickness of the plaster shall be fixed vertically 2.5 to 4 metres apart to act as gauges and guides in applying the plaster. The mortar shall be laid on the wall between the screeds using the plaster's float and pressing the mortar so that the raked joints are properly filled. The plaster shall then be finished off with a wooden straight edge reaching across the screeds. The straight edge shall be worked on the screeds with a small upward and sideways motion 50 mm or 75 mm at a time. Finally, the surface shall be finished off with a plaster's wooden float. Metal floats shall not be used.

When recommencing the plastering beyond the work suspended earlier the edges of the old plaster shall be scraped, cleaned and wetted before plaster is applied to the adjacent areas.

No portion of the surface shall be left out in a condition to be patched up later on.

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required by the Engineer.

The average thickness of plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less than the specified thickness minus 3 mm.

Any cracks which appear in the surface and all portions, which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and re-done as directed by the Engineer.

(5) Curing of Finishes

Curing shall be started as soon as the mortar used for finishing has hardened sufficiently not to be damaged when watered. It shall be kept wet for a period of at least 7 days. During this period, it shall be suitable protected from all damages.

2511. TEST AND STANDARD OF ACCEPTANCE

Before laying any mortar, the Contractor shall make three sets of mortar test cubes from each sourced of sand to demonstrate the compliance of the

mortar to the specified strength. Each set shall comprise two cubes, one to be tested at 7 days and the other to be tested at 28 days. Testing shall be in accordance with IS 2250. During construction the Contractor shall make and test mortar cubes at the rate of three for every 10m3 or part of it of brick work to assess the strength of the mortar subject to a minimum of 3 sample cubes for a days work. The brick shall be tested for compressive strength and water absorption as per NS-1/2035 and shall meet the requirement of this Specification.

2512. MEASUREMENT

All brick work shall be measured in cubic metres.

The work of plastering and pointing shall be measured in square metres separately.

2513. PAYMENT

The brick works, plastering and pointing shall be paid at their respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112 to complete the work as per these Specifications.

Payment for Sub-standard Works

Brick work not meeting the requirements of the relevant Specifications (termed as substandard brick work) shall be paid as substandard work provided it is accepted by the Engineer as substandard work. For the acceptance of such work the Engineer may require further investigation and/or tests which the Contractor shall conduct at his own cost. Acceptance or rejection of such work is the sole responsibility of the Engineer and his decision in this respect shall be the final and binding upon the Contractor.

If accepted as substandard work the payment for such work shall be made at the contract unit rate reduced by the formula given below

$$\text{Percent of reduction, } P = \frac{\text{Design strength of mortar - Observed strength of mortar}}{\text{Design strength of mortar}} \times 100$$

The reduced contract unit rates of substandard brick work and other items contained shall be the full and the final compensation to the Contractor

SECTION 2600 – MASONRY FOR STRUCTURES

SECTION 2600 –BRICKWORKS FOR STRUCTURES

2601. SCOPE

This Section covers the furnishing of materials and construction of different types of stone masonry works in accordance with the Drawing and this Specifications or as directed by the Engineer.

2602. MATERIALS

(1) Stone

The stones to be used shall be durable and angular in shape. If boulders are used they shall be broken into angular pieces. The stones shall be sound, hard, free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. The specific gravity of the stone shall not be less than 2.50. Except otherwise described in the contract, the length of any stone shall not exceed three times its height. The breadth of the stone on the bed shall not be less than 150 mm nor greater than 3/4 the thickness of the wall. At least 85% of the stones used in masonry, except those used for chinking as chips or spalls of stones shall have individual volumes of more that 0.01 m^3. The chips or spalls used including voids in the dry stone masonry shall not be more than 20% of the stone masonry by volume. In case of mortared masonry the total volume of mortar and spalls taken together shall not be more than 30% of the mortared masonry. Representative samples of the stones intended for use in the works shall be submitted to the Engineer for prior approval. Further representative samples shall be submitted for approval whenever there is a change in the type or strength of the rock that the Contractor intends to use in masonry work.

(2) Mortar

Mortar for masonry shall conform to Sub-clause 2502 (2). Sand shall comply with IS 2116 and cement shall comply with Clause 614.

2603. CONSTRUCTION

The method of construction described herein shall hold in all Clauses of this Section, wherever applicable.

(1) General

Construction shall be carried out in accordance with I.S. 1597-1992, Code of Practice for construction of stone masonry, Part 1 Rubble stone masonry or Part 2 Ashlar Masonry as appropriate. All stratified stone possessing bedding planes shall be laid with its natural bed as nearly as possible at right

angles to the direction of load. In the case of arch rings, the natural bed shall be radial. Facework groins shall be built to a height not exceeding one metre in advance of the main body of the work and adjacent walling stepped down on either side. Masonry face work between the groins shall then be built to a height not exceeding 500 mm above the backing which shall then be brought up level with the completed facework. At no time shall the backing be built up higher than the facework.

Except for dry rubble walling, all joints (gaps) shall be sufficiently thick to prevent stone to stone contact and the gaps shall be completely filled with mortar. Stones shall be clean and sufficiently wetted before laying to prevent absorption of water from mortar.

Placing loose mortar on the course and pouring water upon it to fill the gaps in stones shall not be allowed. Mortar shall be fluid, mixed thoroughly and then poured in the joints. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all its faces completely covered with mortar of the thickness as specified for joints.

The bed which is to receive the stone shall be cleaned, wetted and covered with a layer of fresh mortar. All stones shall be laid full in mortar both in bed and vertical joints and settled carefully in place with a wooden mallet immediately after placement and solidly embedded in mortar before it has set. Clean and wet chips and spalls shall be wedged into the mortar joints and bed whenever necessary to avoid thick joints or bed of mortar. When the foundation masonry is laid directly on rock, the bedding face of the stones of the first course shall be dressed to fit into rock snugly when pressed down in the mortar bedding over the rock. For masonry works over rock, a levelling course of M15/40 or M15/20 concrete 100mm thickness shall be laid over rock and then stone masonry work shall be laid without foundation concrete block.

In case, any stone already set in mortar is disturbed or the joints broken, it shall be taken out without disturbing the adjoining stones and joints. Dry mortar and stones thoroughly cleaned from the joints and the stones shall be reset in fresh mortar. Sliding one stone on top of another which is freshly laid, shall not be allowed.

Shaping and dressing of stone shall be done before it is laid in the work. Dressing and hammering of the laid stones which will loosen the masonry, shall not be allowed.

Building up face wall tied with occasional through stones and filling up the middle with stones spalls and chips or dry packing shall not be allowed. Vertical joints shall be staggered. Distance between the nearer vertical joints of upper layer and lower layer in coursed rubble masonry shall not be less than half the height of the course.

Masonry in a structure between two expansion joints shall be carried up nearly at one uniform level throughout but when breaks are unavoidable the masonry shall be raked in sufficiently long steps to facilitate jointing of old and new work. The stepping of raking shall not be more than 45 degrees with the horizontal.

Masonry shall not be laid when the air temperature in the shade is less than 3°C. Newly laid masonry shall be protected from the harmful effects of weather.

(2) Concreting Capping

Where masonry structures are to receive a concrete capping. The joints to the upper surface of the masonry shall be raked out to a depth of 10 mm prior to placing of the concrete to the capping. The concrete for capping shall be as per the Drawing or as directed by Engineer and shall conform to Section 2000.

(3) Pointing

Where external faces of the mortared masonry work will be backfilled or otherwise permanently covered up, the mortared joint shall be finished flush to the faces of the adjacent stonework.

Where mortared masonry faces will remain exposed, the mortar joints shall be pointed to a consistent style as shown on the Drawing. Pointing shall be carried out using mortar 1:3 by volume of cement and sand or as shown on the Drawing. The mortar shall be filled and pressed into the raked out joints before giving the required finish. The pointing, if not otherwise mentioned shall be ruled type for which it shall, while masonry work is still green, be ruled along the centre with half round tools of such width as may be specified by the engineer. The excess mortar shall then, be taken off from the edges of the lines and shall not be unnecessarily plastered over the exposed stone works. The thickness of the joints shall not be less than 3mm for Ashlar masonry.

However, the maximum thickness of joints in different works shall be as follows:

- Random Rubble : 20 mm
- Coursed Rubble : 15 mm
- Ashlar masonry : 5 mm

2604. ASHLAR

All stones shall be dressed to accurate planes on the beds and joints and they shall be fair and neatly or fine tooled on the face unless otherwise described in the contract.

2605. BLOCK-IN-COURSE

Beds and joints shall be squared and dressed for a distance of at least 220 mm from the exposed face. Bond stones shall form at least one sixth of the area of the exposed face and shall extend at least 900 mm into the wall or for the full thickness of the wall if the latter is less than 900 mm. Unless described in the contract as tooled or drafted, the exposed face of all stones shall be blocked and left rough. Arises shall be dressed square at all beds and joints

2606. SQUARE RUBBLE-COURSED OR BROKEN COURSE

All stones shall be truly squared and dressed for a distance at least 120 mm from the face of the wall. Bond stones shall be provided at the rate of at least one to every 0.8 m^2 of exposed face and shall measure not less than 150 mm x 150 mm on the face and not less than 450 mm in length or the full thickness of the wall, whichever is the less. Vertical joints in any layer shall be broken in the next layer and the horizontal lapping of the stones shall not be less than 100 mm

2607. RANDOM RUBBLE-COURSED OR UNCOURSED

All stones shall be carefully set with a bond stone provided at the rate of at least one to every 0.9 m^2 of exposed face. Bond stones shall measure not less than 150 mm x 150 mm on the exposed face and not less than 450 mm in length or the full thickness of the wall, whichever is the less.

2608. DRY RANDOM RUBBLE

Dry random rubble masonry shall be constructed generally to the requirements of coursed random rubble masonry as specified in Clause 2607 but with the omission of mortar. All stones shall be carefully shaped to obtain as close a fit as possible at all beds and joints, any interstices between the stones being filled with selected stone spalls. The stones in courses shall be laid perpendicular to the batter face. The exposed tops or capings of dry rubble structures shall be formed as shown on the Drawing.

2609. COMPOSITE RANDOM RUBBLE

Materials for composite random rubble shall comply with Clause 2602 and construction with Clause 2603. Mortar masonry shall be coursed and comply with Clause 2607 and the dry stone insets with Clause 2608. The dry stone insets shall be constructed when the level of the surrounding mortared masonry surround has reached the top of the dry stone inset.

2610. TEST AND STANDARD OF ACCEPTANCE

Before laying any mortar, the Contractor shall make three sets of mortar test cubes from each source of sand to demonstrate the compliance of the mix to the specified strength. Each set shall comprise two cubes, one to be tested at 7 days and the other to be tested at 28 days. During construction, the Contractor shall make and test mortar cubes at the rate of three cubes for every $10m^3$ of masonry to assess the strength subject to a minimum of 3 cubes samples for a days work. Testing of cubes shall be in accordance with IS 2250. The stones shall be tested for the water absorption as per IS: 1124 and it shall not be more than 5 percent. The stones shall also be tested for Specification gravity and it shall not be less than 2.65. Sand shall be tested as per Clause 613 or as directed by the Engineer. At least 3 set of tests for stone and sand shall be conducted for every source.

About one square meter (1m x 1m) measured in front face of the completed stone masonry in every 200 sq.m or part of it shall be dismantled during the process of construction upto complete depth and the aggregate volume of the stones having volume more than $0.01m^3$ shall be obtained by the method of displacement of water to find the volume of spalls and mortars in the case of mortared masonry and the volume of spalls and voids in the case of dry masonry. The dismantling shall be made in such a manner that the quality of the surrounding work is least affected. While dismantling, the tightness of the joints shall also be compared with the thickness of joints as specified for assessment of the quality of work. If the volume of spalls and mortars is more than the specified volume and/or the joints are not filled completely with mortar, then the entire work which the sample and test represent, shall be rejected.

The dismantled portion shall be made good by the Contractor at his own cost after completion of the test

2611. MEASUREMENT

Stone masonry shall be measured in cubic metres. The pointing shall be measured in sq.m..

2612. PAYMENT

The stone masonry and the pointing shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 112.

Payment for Sub-standard Works

Stone masonry in cement sand mortar not meeting the requirements of the relevant Specifications. (termed as substandard stone masonry in cement sand mortar) shall be paid as substandard work provided it is accepted by the Engineer as substandard work. For the acceptance of such work Engineer may require further investigation and/or tests which the Contractor shall conduct at his own cost. Acceptance or rejection of such work is the sole responsibility of the Engineer and his decision in this respect shall be the final and binding upon the Contractor

If accepted as substandard work the payment for such work shall be made at the contract unit rate reduced by the formula given below

$$\text{Percent of reduction, } P = \frac{\text{Design strength of mortar - Observed strength of mortar}}{\text{Design strength of mortar}} \times 100$$

The reduced contract unit rates of substandard stone masonry in cement sand mortar and other items contained shall be the full and the final compensation to the Contractor

SECTION 2700 – REPAIR OF STRUCTURES

SECTION 2700 –REPAIR OF STRUCTURES

2701. SCOPE

This Section covers the works in connection with the repair of RCC structures such as sealing of cracks, repair and replacement of concrete, cement grouting, gunting/shortcrete. Repair of structures shall be carried out in accordance with the repair plans and these Specifications or as directed by the Engineer.

Implementation of repair schemes shall also conform to provisions of IRC:SP: 40.

2702. GENERAL

(1) Environmental Aspects

Care shall be taken to ensure suitable mitigation measures against noise and dust, pollution and damages to the environs whether temporary or permanent and shall be taken as incidentals to work.

(2) Phasing

The sequence of work shall be in accordance with the Drawing or as directed by the Engineer.

(3) Traffic Management

Traffic management shall be in accordance with Section 100 and shall be considered as incidentals to work.

(4) Safety Precautions

Adequate precautions shall be taken for safety of personnel, road users and existing services, which, during execution, shall be considered as incidentals to work. Persons working shall wear safety helmets and rubber gloves and shall be provided with other safety measures as needed.

(5) Dismantling and Removal of Material

Dismantling and removal of structural shall be executed as per Section 200.

2703. REPAIR OF MINOR DEFECT IN REINFORCED CONCRETE

(1) Preparation of Concrete and Reinforcement

(a) The defective concrete shall be removed by using chipping hammer or by similar method. The edges of the recess shall be cut square or rectangular for a minimum depth of 15mm using an angle grinder or

diamond saw. The surface of the remaining concrete shall be free from loose or shattered aggregate and other unsound material.

(b) Where reinforcement is exposed, the concrete shall be removed for a minimum of a 100mm beyond any corrosion and 25mm behind the reinforcement.

(c) The reinforcement shall be cleaned to remove all corrosion products using abrasive blasting or high pressure water jetting. For small areas scrapers or grinding may be used.

(d) If, as a result of these operations, it is found that the section of a reinforcement bar is significantly reduced, instruction shall be obtained from the Engineer.

(2) Materials

(a) Repair materials for patching shall be a "Prebatched acrylic polymer modified cementious mortar' complying with (b), (c) and (d) below.

(b) The water/cement ratio shall not exceed 0.4.

(c) The cement content shall not be less than 400 kg/m3 of compacted concrete.

(d) Calcium chloride or admixture containing chloride salts shall not be used.

(3) Reinstating the Prepared Areas

(a) Mixing, placing and curing shall be carried out strictly in accordance with the manufacturer instructions with compliance of the followings:

(i) Treatment of existing concrete to prevent suction of moisture from the repair material.

(ii) Manufacturers instructions relating to building up the required depth in layers

(iii) Manufacturers limits on the temperature at which the repair material may be used.

(b) The patch shall be finished off neatly by wooden float to match with the existing profile.

(c) When the repair is set, it shall be stoned down with carborundum stone and dressed over with sand: cement (2: 1). Finally it shall be smoothened with a cement float« very fine carborundum stone until a smooth even face is obtained.

(d) The repaired areas shall be kept damp for 14 days after casting. Propriety membranes shall not be used.

(4) Supervision

All repair shall be supervised by competent and experienced person in carrying out such repair works.

2704. PLACEMENT CONCRETE FOR BRIDGE DECKS

(1) General

Replacement concrete shall be grade M30/10 and/or M30/20 or as specified on the Drawing.

(2) Concrete

The concrete shall comply with Section 2000 depending upon the nature of the work or as directed by the Engineer.

(3) Admixtures

The Contractor shall demonstrate by means of trial mixes the action of the admixture he proposes to use for the Engineer's approval.

(4) Minimum Cement Content and Maximum Water/Cement Ratio

The cement content shall not be less than 400 kg/m^3 of compacted concrete and the water cement ratio shall not be greater than 0.40.

(5) Maximum Chloride Content

The total chloride ion content of the materials shall not be exceed 0.1 percent of the mass of cement. Calcium chloride or admixture containing chloride salts shall not be used.

(6) Placing and Curing

(a) The joint surface shall be saturated of two hours before concrete is placed against it.

(b) Immediately after placing the concrete and for 14 days thereafter, it shall be protected against harmful effects of weather including rain, rapid temperatures changes, frost and from drying out. In all cases the methods of protection used shall be subject to the approval of the Engineer. Proprietary curing membranes shall not be used.

(7) Concrete Strength

The Contractor shall determine average strength in accordance with Section 2000. The strength of the concrete as placed shall be consistent and the deviation shall be within limit of ± 5% of the average strength.

2705. REPLACEMENT CONCRETE FOR THE SIDES AND SOFFITS OF DIAPHRAGMS, AND SOFFITS OF DECKS

(1) General

(a) Replacement concrete shall be of grade M 30/10 and shall be a non-shrink flowable concrete. Materials shall comply with the following requirements.

(b) Cement shall comply with Section 2000 depending upon the nature of work or as directed by the Engineer.

(c) Cement content shall be not less than 400kg/m3 of compacted concrete.

(d) The content of equivalent sodium oxide in the mix shall be restricted or non-reactive aggregates shall be used.

(e) The total chloride ion content of the materials shall not exceed 0.1 per cent of the mass of the cement. Calcium chloride or admixtures containing chloride salts shall not be used.

(f) The aggregate shall be well graded with the maximum size not exceeding 10mm.

(2) Delivery and Storage of Materials

(a) The Contractor shall supply following information with each batch or part of a batch of the material delivered to the site.

(i) Manufacturer’s/supplier’s name and address.

(ii) Manufacturers'/suppliers' name and address where applicable.

(iii) Material identification.

(iv) Batch reference number, size of batch and number of containers per delivery order.

(v) Date of manufacture.

(vi) Chloride contents with evidence.

(b) Containers shall be damp proof and readily emptied of their contents.

(c) Containers shall be marked with the following information:

(i) Material identification

(ii) Batch reference number

(iii) Manufactures'/suppliers' name

(iv) Net weight

(v) Any warnings or precautions concerning the contents

(d) The material shall be stored in a dry place with moderate temperature.

(e) Material shall not be older than 3 months or the period specified by the manufacturer, when incorporated in the works.

(f) The materials shall not be removed from the store for use in the works unless it is immediately required for mixing.

(3) Site Mixing, Placing and Curing

(a) Mixing and placing shall be carried out strictly in accordance with the manufacturer's written instructions together with the followings:

(i) The water cement ratio shall not exceed 0.4. The water content shall be determined during Approval Tests, approved by the Engineer.

(ii) The material shall be incorporated in the works within 20 minutes of completion of mixing, or within the period as specified by the manufacturer.

(iii) No extra water shall be added after the original mixing.

(iv) The material shall not be mixed or placed in the works at ambient temperatures lower than $5^{o}C$.

(v) The surface temperature of the concrete shall be maintained at not less than $5^{o}C$ until the concrete reaches a strength of $5N/mm^2$ as determined by tests of cubes cured under similar conditions.

(b) Replacement concrete shall not be placed against other concrete which has been in position for more than 30 minutes unless a construction joint is formed. In addition, the joint surface shall be saturated for a minimum 2 hours before concrete is placed against it. When

replacement concrete has been in place for 4 hours, no further concrete shall be placed against it for a further 20 hours.

(c) Vibration shall not be used

(d) Immediately after placing, the concrete shall be protected for 14 days against harmful effects of weather including rain, rapid change of temperature, frost and from drying out. The methods of protection used shall in all cases be subject to the approval of the Engineer. Proprietary curing membranes shall not be used.

(e) When the mix proportions have been approved by the Engineer no variations shall be made in the manufacture, supply, mix proportions or method of the material without the consent of the Engineer.

(4) Approval Tests

(a) Before work commences on the site all properties of the proposed replacement concrete shall be demonstrated by the Contractor and the manufacturer's representative by carrying out the tests specified below. Where required in the contract, procedure trial shall be carried out on the model specified in the contract or modified to suit actual reinforcement details or working condition.

(i) The tests shall be carried out in the presence of and to the satisfaction of the Engineer who shall receive certified copies of the results of all tests.

(ii) The mixer and method of mixing shall be the same as that to be used in the works.

(b) Flow Through Test

(i) For each flow test, sufficient quantity of the replacement concrete shall be mixed in a mixer approved by the manufacturer.

(ii) The flow characteristics of the concrete shall be assessed at an ambient temperature of between 5^{o}C and 20^{o}C in the flow trough indicated in the contract.

(iii) The temperature of the materials and mixer shall be as close as possible to those expected during the contact with the original surface.

(iv) The funnel shall be fitted with a rubber bung and charged with 6 litres of concrete. On the release of the bung the concrete shall flow along the trough and the length of the flow shall be measured. The minimum length of flow along the trough for

each test shall be 450mm, without signs of segregation or bleeding.

(c) Flow Tests for Horizontal Soffit Surfaces.

The flow characteristics for repairs to soffits shall be assessed by pouring the concrete mix. The pre-cast concrete slab shall be wetted for 2 hours before the test, but the surface shall be free of surplus water at the time of test. The concrete shall be poured from one side of the model until the level of the concrete has reached at least 10 mm above the underside of the top plate. The material shall be placed in the model in one pour.

After 24 hours the top plate shall be removed and the exposed surface shall be lightly brushed with a stiff bristle brush to remove any surface cement skin which may be covering voids. The exposed surface of the concrete shall be examined for air-pockets, cracks and other defects.

- The temperature of the mixer and material for each test shall be as in Sub-clause 2705 (4) (b).

- The trial shall be deemed successful if the concrete thus formed is homogeneous and free from air-pockets

(d) Compressive Strength Tests

(i) These shall be carried out to determine the compressive strength of the concrete at 20°c.

(ii) Test cubes shall be made in 100 mm metal moulds to BS 1881: Part 108. The moulds shall be carefully filled by pouring concrete through a funnel to produce void free specimens. There shall be no compaction. The cubes shall be cured in accordance with BS 1881: Part 111. Testing shall be carried out in accordance with BS 1881: Part 116.

(iii) The specified minimum strength shall be established using a set of three cubes. The requirement shall be satisfied if none of the compressive strengths obtained is lower than the specified value, and the difference between the highest and lowest values shall not be more than 20% of the average.

(5) Batch Acceptance Tests

(a) The material shall be taken at random from one or more containers from the same batch. Each batch of material delivered to the site shall be tested as specified below.

(b) Flow trough test shall be carried out as specified in these Specifications.

(c) Flow tests for horizontal surfaces shall be carried out as specified.

(d) Compressive strength tests shall be carried out as specified

(6) Site Tests

Three cubes from each batch mixed for placing in the Works shall be tested for compressive strength.

(7) Concrete Strength

(a) The Contractor shall determine this average strength in accordance with these Specification. The strength of the concrete as placed shall be consistent and the deviation shall be within limit of ± of the strength.

2706. SEALING OF CRACKS BY INJECTION OF EPOXY RESIN

(1) General

The work of epoxy adhesive for the Structural Concrete Bonding Process shall conform to these Specifications.

The Contractor shall furnish detailed methodology of construction including source of supply of material, tools, equipment and appliances with details of personnel and supervision to be used on work.

(2) Personnel

The Contractor's personnel shall be qualified and experienced in epoxy injection process.

(3) Materials

The materials for injection shall be a suitable two-component low viscosity epoxy resin, having the required characteristics of bonding with concrete and resistance to moisture penetration. Epoxy mortar or polysulphide resin may be used for sealing the surface.

The material for epoxy injection shall conform to the following:

(i) The mixing ratio of resin and hardener shall generally be between 1 to 1 and 2 to 1 by volume subject to manufacturer’s recommendation.

(ii) Neither the mixed epoxy adhesives nor their individual components shall contain solvents and thinners.

(iii) The components shall be free of foreign material. The viscosity of the individual components shall not change more than ±15 percent when kept in closed containers at 25 degrees Celsius after two weeks.

(iv) Pot Life of Mixed Adhesive at 25 degrees Celsius - 1 hour ± 15 minutest*

(v) Set time of mixed Adhesive at 25 degrees Celsius - 3 to 6 hours

(vi) Consistency Requirement

Viscosity of Mixed Adhesive at 25 degrees Celsius	Standard Version (cps)	Low Viscosity Version (cps)
	(200 – 300)	(100 – 190)

** In the case of two component injection system where resin and hardener get mixed at point of injection pot life at 25 degrees Celsius shall be not greater than 15 min ± 10 minutes.*

(4) Equipment for Injection

The equipment shall be a portable, positive displacement type pump with interlock to provide positive ratio control of exact proportions of the two components at nozzle. The pumps shall be generally electrically powered and shall provide in-line metering and mixing. The tolerance on mix ratio shall be 5 percent by volume. The injection equipment shall have automatic pressure control capable of discharging mixed adhesive at any pre-set pressure within the prescribed limits and shall be additionally equipped with a manual pressure control.

The injection equipment shall be equipped with sensors on both the components. A and B reservoirs i.e. reservoirs containing components resin and hardener shall automatically stop the machine when only one component is being pumped to the mixing head.

If considered appropriate, suitable compressed air operated epoxy injection gun can be used with prior approval of the Engineer for manual injection of mix when resin and hardener had been mixed in a separate unit.

(5) Preparation

Surfaces adjacent to cracks or other areas of application shall be cleaned of dirt, dust, grease, oil efflorescence or other foreign matter by brushing/water jetting/sand blasting. Acids and corrosives shall not be permitted for cleaning.

Entry ports shall be provided along the crack at intervals of not more than the thickness of concrete at the location.

Surface seal material shall be applied to the face of the crack between the entry ports. For through cracks, surface seal shall be applied to both faces.

Before proceeding with the injection, the surface seal material must gain adequate strength with respect to concrete strength of the member and injection pressure

(6) Epoxy Injection

Injection of epoxy adhesive shall begin at lowest entry port and continue until there is an appearance of epoxy adhesive at the next entry port adjacent to the entry port being pumped.

When epoxy adhesive travel is indicated by appearance at the next adjacent port, injection shall be discontinued on the entry port being pumped and entry port shall be sealed. Thereafter, epoxy injection shall be transferred to next adjacent port where epoxy adhesive has appeared.

Epoxy adhesive injection shall be performed continuously in this manner until cracks are completely filled.

If port to port travel or epoxy adhesive is not indicated the work shall be immediately stopped. In case the volume of the injected exceeds 2 litres for a particular entry port, the work shall be stopped and the Specifications shall be reviewed.

(7) Precautions during Application

(a) Unless otherwise specified, at the time of mixing components A and B, i.e., resin and hardener, shall be at a temperature between 10 and 35 degrees Celsius.

(b) Temperature of structural member during epoxy injection shall be between 10 and 35 degrees Celsius unless otherwise specified.

(c) Immediately prior to use, each component shall be thoroughly mixed with a clean paddle. The paddle shall be of a type that does not induce air into the material. Separate clean paddle must be used for each component.

(d) Any heating of the adhesive components may be done by application of indirect heat in case the work is to be done in cold climate.

(e) Just before use, the two components shall be thoroughly mixed in the rations specified by the manufacturer. The mixing time shall be in strict accordance with manufacturer's recommendations. When mixed, all adhesives with different coloured components shall have a uniform colour without streaks.

(f) The use of solvents and thinners shall not be permitted except for cleaning of equipment

(8) Testing

(a) Material Testing

Prior to approval of the material, the following tests shall be carried out at site or in an authorised laboratory for each batch of resin and hardener and each combination thereof at the cost of the Contractor.

(i) Viscosity test for resin and hardener and the mix - three specimens each.

(ii) Pot life test - three specimens each.

(iii) Bond test - three specimens each.

(iv) Shear test - six specimens each, 3 after 24 hours and the other three after 72 hours of curing.

Subsequent tests shall be carried out as directed by the Engineer.

Plot Life Tests

(i) 500 gm of resin formulation shall be prepared by thoroughly mixing the resin and harderner/accelerator/catalyst component in proposed proportion in a 1 kg capacity hemispheral porcelain bowl by means of a spatula or any other agitating device. The time and the ambient temperature shall be noted down.

(ii) With a clean dry 25 mm size painter's brush, the resin formulation shall be applied on a clean dry surface such as cement concrete over 15-20 cm length, starting immediately after mixing the formulation and repeating operation every five minutes. When it becomes just difficult to spread the resin properly with the brush, the time is noted. The time elapsed since completion of mixing of resin formulation is taken as its pot life.

(iii) One pot life test shall be performed on commencement of work and the same shall be repeated every four hours.

(iv) In case the material fails to satisfy the pot life test it shall not be used for injection

Where the resin and hardener get mixed at point of injection, the pot life is not important and no tests may be required

Bond Test

A standard 150 mm diameter and 300 mm long concrete cylinder shall be cast in 2 pieces by providing a separating media at an axis of 45 degrees to the longer axis of the cylinder.

Three sets of such split cylinders shall be prepared in advance. Two pieces of each set shall be joined with epoxy mortar at four points to give a clear gap of about 0.2 mm, which shall be injected with epoxy resin at site. After epoxy has been cured, load test shall be carried out on the cylinder which shall not be less than 80 percent of the cube strength of the concrete mix and the failure shall not take place at the joint injected with epoxy resin.

Shear Tests

Two steel plates, minimum 3 mm thick, shall be bonded with epoxy at site using the same resin mix as used/proposed to be used for injection. The assembly shall be kept in mechanical clamp till epoxy is cured. A total of six specimens shall be prepared for each batch of materials. Three test specimens shall then be subjected to a shear force along the axis after 24 hours and minimum shear stress before failure shall not be less than 1 N/sq.mm.

The remaining test specimens shall be similarly tested after 72 hours of curing. The shear stress before failure shall not be less than 2.5 N/sq.mm.

(b) Core Test

If directed by the Engineer, core tests shall be conducted for the acceptance of the work. The selection of the location of cores shall be made under the direction of the Engineer in such a way that damage in critical/stressed areas of the structure is avoided. The procedure for the test shall be as under.

The Contractor shall obtain 5cm diameter initial core samples in the first 50 linear metres. Thereafter, frequency of core sampling shall be as specified or as agreed by the Engineer.

The depth of the core shall generally be less than 20cm.

Tests and Acceptance Criteria shall be as follows:

(i) PenetrationNisual Examination - a minimum of 90 percent of the crack shall be full of epoxy adhesive.

(ii) Bond Strength: Concrete failure before adhesive failure or 40 Mpa with no failure of either concrete or adhesive.

If the cores taken in first 5am length pass tests as specified above, epoxy adhesive injection work at area represented by cores shall be accepted.

If cores fail either by lack of penetration or bond strength, work shall not proceed further until the areas represented by the cores are reinjected and retested for acceptance.

Filling of core holes shall consist of using two-component bonding agent applied to surfaces of cored holes followed by application of Non-Shrink cement grout mix placed by hand trowel, thoroughly rodded and tamped in place, and finished to match finish and texture of existing concrete to the satisfaction of the Engineer. Materials and procedures for filling testing core holes shall be submitted to and approved by the Engineer before proceeding with core testing work.

(c) Test for Injection Equipment

At all times during the course of the work the Contractor shall keep complete and accurate records and make available to the Engineer of the pressure and ratio tests specified above so that the efficacy and accuracy of the injection equipment is verified.

In addition, the Engineer at any time without prior intimation of the Contractor may request the Contractor to conduct the tests specified below, in his own presence.

(i) Pressure Test

The mixing head of the injection equipment shall be disconnected and the two adhesive component delivery lines shall be attached to the pressure check device, which shall consist of two independent valved nozzles capable of sensing the pressure. The check device shall be closed and equipment operated until the gauge pressure in each line reads 5MPa. The pumps shall be stopped and the gauge pressure shall not drop below 4 MPa within 2 minutes.

The pressure test shall be run for each injection unit at the beginning and after break of every shift

(ii) Ratio Test

The mixing head of the injection equipment shall be disconnected and the two adhesive components shall be pumped simultaneously through the ratio check device, which shall consist of two independent valved nozzles. There shall be a pressure gauge capable of controlling back pressure by opening or closing valved nozzles capable of sensing the back pressure behind each valve. The discharge pressure shall be adjusted to read 5 bar for both adhesive components. Which shall be simultaneously discharged into separate calibrated containers during the same time period and the amounts discharged into the calibrated containers simultaneously during the same period shall be compared to determine that the volume/discharge conforms to the manufacturer's recommended ratio for applicable material.

2707. EPOXY MORTAR FOR REPLACEMENT OF SPALLED CONCRETE

(1) Material

(a) Formulation

The epoxy resins for use in the mortar shall be obtained from a reputed manufacturer and the mortar shall be prepared in conformity with the manufacturer's recommendations.

They shall generally conform to the following:

Pot Life	:	90 minutes at 25 degrees Celsius. 60 minutes at 30 degrees Celsius. 45 minutes at 35 degrees Celsius.
Bond Strength	:	12 N/sq.mm `
Tensile Strength	:	16 N/sq.mm

The Contractor shall carry out tests on the samples made out or requirements indicated above. The sand content in the mortar shall be in accordance with the desired consistency.

(2) Proportioning and Mixing

The resin and hardener shall be mixed before adding the dry filler. The mixed ready to use mortar shall not contain lumps of unwetted filler and should be uniform in colour. For a total weight of 1 kg or less, hand mixing shall be sufficient. For quantities in excess of 1 kg, the component shall be mixed for 3 minutes with a slow speed 400-600 rpm electric drill with a

Jiffy mixer. The stirrer shall be moved up and down and along the sides until an even steak free colour is obtained. Whipping In an excessive amount of air shall be avoided. If no power is available, a flat putty knife may be used to reach into the corners of the can and hand mixing done for at least 5 minutes.

(3) Surface Preparation

Surface upon which epoxy is to be placed shall be free of rust, grease, oil, paint, asphalt, loose or material, unsound concrete, dust or any other deleterious material.

Since cured epoxy does not provide adequate bond with any material, all overlay, whether epoxy or cement based, shall be done within pot life of the base epoxy layer.

Contaminants, such as oil, grease, tar, asphalt, paint, wax, curing compounds of surface impregnates like linseed oil or silicons, including laitance and weak or loose concrete shall be removed. When bonding to asphalt, the surface should be roughened so that clean aggregate is exposed. Epoxy bonding agents shall not be applied when it rains, or in standing water. The surface must be dry.

Two general methods of surface preparation shall be followed:

(a) Mechanical that includes grinding, grit blasting, water blasting and scarification.

(b) Chemical that includes acid etching with 15 percent by weight of hydrochloric solution, followed by repeated flushing with high pressure stream of water.

(4) Application

Epoxy primer coat shall be applied with the help of stiff nylon bristle brushes or hard rubber rollers or spray gun depending upon the nature of surface and extent of work area. As far as possible, the coating shall be uniformly thick.

Before the primer coat is fully cured, epoxy mortar shall be applied by means of trowels and floats. The interval between the application of primer coat and epoxy mortar shall be approximately 15/30 minutes depending upon the ambient temperature.

Seal coat shall be applied after 24 hours curing, after mild roughening of the surface of the mortar.

(5) Coverage

The coverage of resin mix will depend on the system of resin used. However, as a general guideline the coverage area shall be as under:

(a) Primer Coat. One kg of resin-hardener mix covers an area of 3-6 square metres per coat depending on the finish of the concrete.

(b) Epoxy Mortar. One square metre of surfaces requires approximately 20-24 kg of epoxy mortar when laid to a thickness of 10mm.

(c) Seal Coat. 4 to 6 square metres per kg of mix depending on the temperature of application.

(6) Cleaning and Maintenance of Equipment

Tools and equipment are best cleaned immediately after use since the removal of cured resin is difficult and time consuming. The bulk of resin shall be removed using a scraper and remainder washed away completely using solvents such as toluene, xylene or acetone. Equipments used for epoxy shall always be cleaned before it hardens. Solvents used for this purpose may be Acetone (flammable), Methy/Ethy/Kethone (flammable), Methyle Chloride (non-flammable). Cured epoxies may be removed using Methylene Chloride.

(7) Testing

Epoxy used for making mortar shall conform to all requirements and testing procedures as laid down in Sub-clause 2706 (8).

(8) Handling Precaution

Epoxy resins may cause irrigation of skin in sensitive persons if incorrectly handled. The resin and hardener should not be allowed to come into direct contact with skin. The most effective protection is achieved by wearing rubber or polythene gloves.

(9) Personnel and Environment Safety

Any skin contact with epoxy materials, solvents and epoxy strippers shall be avoided. Epoxy resins and particularly epoxy hardeners (B component) may cause a rash on the skin. The official toxicity classification on the container labels should be looked for before starting work.

Rubber gloves with a cloth liner and protective clothing shall be worn. Barrier creams are recommended but are not substitutes for protective clothing. Eyes shall be protected where splashing could occur while spraying or mixing. Good ventilation shall be ensured and inhalation of vapours shall be avoided. If materials are sprayed, a respirator shall be used.

If skin contact occurs, it shall be immediately washed with a cleaner, followed by soap and water. Should eye contact occur, it shall be flushed immediately with plenty of water for 15 minutes and a doctor called for.

If contact occurs with the clothing, it shall be immediately changed to prevent further skin contact, and if the contact occurs with components A or B, the clothing shall be thrown away. Hardened epoxy is not harmful but will break the clothing.

All emptied, used buckets, rags and containers shall be removed from site. These shall be stored in waste disposal bags and suitably disposed.

2708. EPOXY BONDING OF NEW CONCRETE TO OLD CONCRETE

(1) Epoxy resin used bonding shall be obtained from a reputed manufactures. The pot life of such bonding epoxy shall be more than 60 minutes at normal temperature.

(2) The entire surface of the existing concrete member shall be thoroughly cleaned by wire brush and then with compressed air to remove dust and loose particles from the surface. Any crack or spalling of concrete shall be seated by epoxy injection/epoxy mortar/grouting as decided by the Engineer. A coating of suitable epoxy resin at the rate of 0.8 kg/sq.m (minimum) shall then be applied on the surface of the existing concrete members. Fresh concrete shall then be placed within the pot life of the resin system.

(3) Testing

Epoxy used for bonding work shall satisfy the criteria mentioned in Clause 2706 (8).

Two concrete cubes of 150 mm size as per approved design mix shall be placed, at a distance of 150 mm from each other. Epoxy resin system suggested for bonding new to old concrete shall be applied on the opposite faces of the cubes.

Fresh cement concrete cube of grade as per approved design mix shall be water cement ratio of 0.4 or less in between two concrete cubes already casted and epoxy resin applied bor bonding on a 12 mm thick steel spacer. The assembly shall be cured in water for 28 days and steel spacer removed thereafter.

The cube assembly shall be subjected to compression load after 28 days of curing, thereby subjecting the bond to shearing load. Failure must not occur at this joint.

2709. CEMENT GROUTING

(1) Material

Grouting shall normally be performed with a mixture of neat Portland cement and water. Other additives and admixtures may be added to improve the impermeability, strength, etc. on the approval of the Engineer. The size of the particles and the consistency of the grout must be suited to the passageways it must follow. Neat grout shall not flow freely into holes smaller than about three times the largest cement particle. Except in large cavities where thick mortar can be placed, the sand shall all pass the 28-mesh sieve and have a large portion passing the 50 and the 100 mm sieves. The proportions of ordinary Portland cement to sand will depend upon the size of the spaces to be filled and will vary from a neat grout to about 1:1 mix. The amount of water to be added depends upon the consistency required. Grouts with as little as 16 litres of water per bag of cement can be handled. It may not be required to use more than 40 litres of water per bag of cement.

Where necessary and approved by the Engineer, admixtures to Portland cement grout mixtures may be added for delaying the setting time, increasing flow ability, minimising segregation and shrinkage.

(2) Preparation

The surface shall be cleaned with wire brush and compressed air 15 mm dia and 150 to 200 mm deep holes along the length of the cracks at a spacing of 500 mm shall be drilled by wet drilling using rotary percussion drills. Nipples shall be inserted in these holes.

(3) Proportioning, Mixing and Equipment for Grouting

The cement grout shall be mechanically mixed using a system of power-driven paddles of high-speed centrifugal pump. The grout pump to be used shall permit close control of pressures toallow a flexible rate of injection with minimum clogging of valves and ports. The most satisfactory equipment for injecting grout is a pump of the double-acting flexible reciprocating type giving a steady flow. The grout pumps shall be so placed as to reduce the waste in cleaning lines. It is preferable to add 50 percent or more of the mixing water into the mixer before adding the dry ingredients and then the remaining water. A continuous supply of grout is preferable to an intermittent one. Consistency of the grout shall be determined by trials starting with thin grout i.e. about 40 litres of water per bag of cement and progressively decreasing the water content to about 15 litres per bag of cement.

Where the mixer and pump are combined in one unit, the dry material shall be screened before mixing. If the mixer and pump are in separate units, the grout shall pass through a screen before it enters the pump.

(4) Application

Highest practical pressure within the limits 0,10 - 0.40 N/mm^2 should be used in order to force the surplus water from the grout. As the pressure may be distributed hydraulically over considered areas, vigilance must be exercised to prevent damage or the needless waste of grout. Grouting is to be done by attaching a packer (consisting of expansible tube or rubber) to the end of the grout supply pump through the holes and nipples.

Pressure shall be steady to ensure a continuous flow of grout. Grouting shall be continued till the hole consumes mix at the rate of not less than 30 litres in 20 minutes or until refusal at the grouting pressure of 400 kPa at any hole until refusal. Should the grout escape from an adjacent nipple, it should be plugged or capped. Any seam, crack or joint through which grout escapes shall be caulked with epoxy mortar as soon as thick grout appears.

(5) Cleaning of Equipment

After completion of each grouting operation or temporary shutdown, it is advisable to force clear water through the pump until the discharge lines shows no colour, after which the pump covers shall be removed and the valve chambers thoroughly cleaned.

(6) Testing

Percolation test done at the end of grouting operation shall give a value of less than 2 lugions.

***Note**: For specialised treatment like polymer modified cementiitious grout injection, manufacture's literature and Specification shall be followed.*

2710. GUNITING/SHOTCRETE

(1) Material

The gunite is a mixture of cement, sand and water. It shall comprise of 100 parts by weight of cement, 300 parts by weight of quartz sand, 35-50 parts by weight of water and 2 parts by weight of approved quick setting compound. In general, dry mix shortcrete shall be used.

Ordinary Portland cement conforming to IS: 269 shall be used in guniting.

Sand for guniting shall comply with the requirements stipulated in IS:383. In general, sand shall neither be too coarse to increase the rebound nor too fine to increase the slump. Sand shall have a moisture content between 3 to 6 per cent.

The grading of sand shall lie within the limits given in Table 27.1.

Table 27.1 : Grading of Sands

Sieve Designation	Per cent Passing the Sieve
4.75 mm	95 – 100
2.36 mm	65 – 90
1.18 mm	45 – 75
0.600 mm	30 – 50
0.300 mm	10 – 22
0.150 mm	2 – 8

For thick sections it may be advantageous to incorporate coarse aggregate in the mix provided adequate guniting equipment is available. Coarse aggregate, when used, shall conform to grading given in Table I of IS: 9012. The percentage of coarse aggregate shall be kept as 20 to 40 percent of the total aggregate and the mix shall be suitably designed.

Water/cement ratio for guniting shall fall within the range 0.35 to 0.50 by mass, wet enough to reduce the rebound. Drying shrinkage may be between 0.06 percent to 0.10 percent. The quick setting compound shall be added at the nozzle with water just before guniting.

(2) Workmanship

The cement and sand shall be batched and mixed and conveyed through a hosepipe with the help of compressed air. A separate line shall bring the water under pressure. The cement, sand water mix shall be passed through and intimately mixed in a special manifold and then projected at high velocity to the surface being repaired. The density of gunite shall not be less than 2000 kg/cu.m. The strength of gunite shall not be less than 25 N/mm^2. For effective guniting, the nozzle shall be kept 60 to 150 cm away from the surface, preferably normal to that surface. While enclosing reinforcement bars during repairs, the nozzle shall be held closer at a slight angle and the mix shall be wetter than the normal.

Test panels simulating actual field conditions shall be fabricated for conducting pre-construction testing. The procedure for testing the cubes or cylinders taken from the panels stipulated in Clause 6 of IS: 9012 shall be followed.

It shall be ensured from tests that strength of about 25 N/mm^2 at 28 days is available for the mortar/concrete mix.

The defective concrete shall be cut out to the full depth till sound concrete surface is reached. Under no circumstances the thickness of concrete to be removed shall be less than clear cover to the main reinforcement. No square shoulders shall be left at the perimeter of the cut-off portion and all edges

shall be tapered. Thereafter, all loose and foreign materials shall be removed and the surface be sand-blasted to make it rough to receive shotcrete after applying a coat of bonding epoxy as per recommendation of the manufacturer at the rate of 1.0 kg per 1.5 sq.m. of surface area.

The exposed reinforcement shall be thoroughly cleaned free of rust, scales etc. by wire brushing. Wherever the reinforcements have been corroded, the same shall be replaced or supplemented by additional reinforcement. Before application of gunite, a coat of neat cement slurry shall be applied on the surface of the reinforcement.

Sufficient clearance shall be provided around the reinforcement to permit encasement with sound gunite. Care shall be taken to avoid sand pockets behind the reinforcement.

A thickness of 25 to 40 mm of gunite can normally be deposited in one operation. If, for some reason, the total thickness is to be built up in successive operations, the previous layer shall be allowed to set but not become hard before the application of the subsequent layer. It shall always be necessary to apply guniting on a damp concrete surface.

Where required, welded wire fabrics 5cm x 5 cm x No.1 0 gauge shall be provided in the first layer of guniting. The fabric shall be tied properly. In case the damage to the concrete member is too deep, the Specifications for guniting as well as requirement of placement of wire mesh has to be decided as per field conditions.

The stipulations given in IS: 9012 regarding application of gunite shall be followed so as to keep the rebound to the minimum. The quality of guniting and workmanship shall be such that the percentage of rebound mentioned in IS 9012 is adhered to. In no circumstances shall be rebound material be re-used in the work.

It would be desirable that green gunite is moistened for at least 7 days. Guniting work shall not with be done during windy rainy conditions

2711. REPLACEMENT/RECTIFICATION OF BEARING

The replacement/rectification of bearings shall be carried out in accordance with approved repair plan or as approved by the Engineer.

Lifting of superstructure spans may be carried out by jacking up from below or by lifting the span from top. Where jacks are employed, their location/number and size shall be selected in such a manner that no undue stresses are created in the structure. Jacks may be placed on piers/pier caps or specially erected trestles in accordance with the approved methodology for lifting of superstructure. All jacks shall be operated from one control panel by a single control lever. The system shall have provision for manual over ride to control the loads of any particular

jack. The jacks shall be so synchronised that differential lift between individual jacks shall not exceed 1 mm.

Necessary repair/replacement of bearings shall be carried out as indicated in the repair plan or a directed by the Engineer. Care shall be taken to plan the execution of repair in the shortest possible period.

Precautions during lifting of Girders for Rectification of Bearings

Walkie-talkies system or similar audio arrangements should be available for communicating instructions regarding lifting, stopping, starting etc. The operator shall have a clear view of the jacks and the lifting of each girder so that the lifting is controlled by reading the dial gauges.

2712. DISMANTLING OF CONCRETE WEARING COAT

(1) Commencement of Dismantling

(a) Before commencing dismantling, the nature and condition of concrete, the condition and position of reinforcement shall be ascertained. The Contractor shall familiarise himself with the structural design and ensure that the overall stability of the bridge is not affected.

(b) The existing expansion joint assemblies shall be removed carefully along the entire width of the carriageway. The deck slab for a width of 400 mm on either side shall be removed for placing of reinforcement, anchor rods, anchor bolts and other filling assemblies for the new expansion joints and pouring of fresh concrete. The gap between the girders over the piers shall be cleared of all debris. A temporary platform in the gap at the end of girders shall be erected to collect the materials falling down during concreting and fixing of expansion joints.

(c) The service lines, if any, shall be disconnected/diverted before the dismantling work starts.

(2) Safety of Existing Structures

Dismantling of concrete wearing coat shall be carried out using jackhammers or suitable manual methods as approved by the Engineer. Care shall be taken to avoid any damage to the existing structure including reinforcement or pre-stressing anchorage for cables if any, located in the deck slab.

(3) Precautions During Dismantling Work

For general guidelines, reference may be made to Section 200. Dismantling work shall not be carried out at night, or during storm or heavy rain. A

warning device shall be installed in area to be used to warn the workers in case of mishap/emergency.

Safety helmets conforming to IS: 2925 shall be used by the workmen engaged in dismantling work. The sheds and tools boxes shall be located away from the work site. Goggles preferably made up of celluloids and gas masks shall be worn at the time of dismantling, especially where tools like jack hammers are deployed to protect eyes from injuries from flying pieces, dirt, dust etc. Leather or rubber gloves shall be worn by the workers during the demolition of RCC work. Screens made up of GI sheets shall be placed wherever necessary to prevent the flying pieces from injuring the workers.

Water shall be sprayed to reduce the dust while removing concrete wearing course with jack hammer. No other work shall be taken up under the span when dismantling work is in progress.

2713. PAINTING OF STEEL BRIDES

(1) General

The Contractor shall use the Paint System as described in Sub-clause 2713 (2) for the repainting of the existing bridge structure, to complete the work in at least 4 separate coats as specified below.

The painting of the structure shall include the removal of existing paint coats and preparation of the metal surfaces, the application, protection and drying of the paint coats; the protection of pedestrian, vehicular or other traffic on or underneath the structure; the supply of all tools, equipment, scaffolding, labour and materials (including paint as specified) necessary for completion of the work involved in painting the surfaces of the structure.

(2) Paint System

The paint system be supplied by the Contractor shall comprise as given in Table 27.2.

Table 27.2: Paint System

Coat No.	Type	No' coats	DFT*, microns
1	Epoxy Red Oxide Zinc Phosphate Primer	1	30
2	2 pack High Build Epoxy	1	75
3 and 4	2 Pack Acrylic Polyurethane	2	35/coat

**DFT – Dry film thickness of the paint coating*

The system shall provide a total minimum dry film thickness of 200 microns, and shall include for all approved thinners and cleaning agents necessary for the completion of the work in accordance with these Specifications.

The Contractor shall be responsible for apprising himself of the specified paint system and the manufacturers recommendations in respect of its storage, preparation, application, and protection and shall take all necessary measures and precautions to ensure compliance with the manufacturers recommendations.

(3) Paint Supply

The paint shall be supplied by the Contractor in sealed containers of not more than 5 litres capacity and these shall be used in the order of delivery. Each container shall be clearly marked on the side to show the name of the manufacturer, registered description of the material (including purpose, e.g. whether primer, undercoat or finish), colour, batch number and date of manufacture.

(4) Storage of Paint

Where the Contractor requires to store paint, the paint shall be stored in a secure paint store and ventilation provided as necessary to maintain the temperature of the paint store at a temperature between 5 and 25 degrees Celsius. If at any time whilst within the Contractors possession paint is allowed to exceed these limits, the paint shall be removed from the Works at the Contractors expense and the cost of the paint, as determined by the Engineer, shall be debited to the Contractor.

Paint, which has not been used within 12 months of the date of manufacture or the shelf life recommended by the manufacturer, whichever is the lesser, shall not be used in the works.

At the end of each working period, paints which shall have exceeded their "pot life" by the commencement of the next working period shall be mixed with fresh paint but shall be removed from the works at the Contractor's expense.

Other types of paints shall be returned to store and kept in sealed containers with not more than 10% usage.

The Engineer shall have access to the Contractors secure paint store at all times.

(5) Preparation of Surface

(a) Standard of Surface finish

Unless otherwise instructed by the Engineer, the Contractor shall prepare all steel surfaces of the structure, including existing paint coatings applied over a steel substrate, to the standard described below for the appropriate paint system.

Unless otherwise specified or instructed, fasteners shall be prepared and painted to the same standard as adjacent main surfaces.

Prior to coating the finished prepared surfaces shall be free of contamination, detrimental to subsequent paint coatings, to the satisfaction of Engineer.

The surface shall be free from dust and grit and dry and ready for painting.

Surface preparation shall be continued until the specified standard of surface finish has been achieved and approved by the Engineer.

(b) Preparation by Blast Clearing

Preparation by blast cleaning shall be used. Unless otherwise instructed by the Engineer, the Contractor shall prepare all steel surfaces, including existing paint coatings applied over steel substrate, down to clean steel.

The quality of finish required for steel surfaces to be painted shall be to the British Standard BS 7079 (Group C and D) (or equivalent Specification approved by the Engineer).

Mill scale, rust and foreign matter shall be removed to the extent that only slight traces are remaining as stains in the form of spots and strips. The surface shall be cleaned with a vacuum cleaner, dry clean compressed air or a clean brush.

Surfaces shall be virtually free from sharp spikes of parent metal defined as 'rogue peaks' (formed by the impact of abrasive particles and which project above the blast cleaning profile) hackles and inclusions, and any such irregularities which in the opinion of the Engineer would be detrimental to the protective system shall be removed.

The maximum amplitude of the surface measured between peaks and adjacent troughs after surface preparation shall be not greater than 50 microns when measured by an approved surface profile comparator, unless otherwise approved by the Engineer. In any event the maximum amplitude shall not exceed 100 microns.

Prepared surfaces assessed as unsatisfactory shall be blast cleaned again with fresh abrasive.

Preparation of the steel surface for painting shall, unless otherwise approved by the Engineer, be by blast cleaning using a dry air/abrasive system,

Abrasives used for blast cleaning shall be either clean, dry sand, mineral grit, steel shot or steel grit at the option of the Contractor and shall be of a grading suitable to produce satisfactory results. The use of other abrasives shall be permitted only with the approval of the Engineer.

It shall be the Contractor's responsibility to provide the approved abrasive materials in the quantity and quality necessary to complete cleaning operations to the satisfaction of the Engineer.

Unwashed sands containing salts or excessive amounts of silt shall not be approved.

Unless otherwise approved by the Engineer, non-metallic abrasives shall not be recycled.

(c) Procedures for Treatment of Areas of Mechanical damage or Other Surface Defects

Score marks and indentations in the surface of a steel substrate shall be treated by abrading or grinding to bright steel to produce a surface without short edges or abrupt changes in contour. Damage to unprepared surfaces shall be treated before blast cleaning. Other surface defects in the steel substrate, including fissures caused by the removal of hackles or inclusions shall be similarly treated subject to the approval of the Engineer.

In the case of damage to the paint coating only, surface preparation shall be done by abrading or other method as agreed with the Engineer. The paint coatings shall then be restored in accordance with the Specification.

In all cases where paint coats only are to be restored, the edges of paint coatings shall be bevelled back into sound paint

(6) Testing of Paints

The Contractor shall provide 500 ml samples for laboratory testing purposes of each type of paint to be used in the works. The samples shall be taken from the first batch of each type of paint delivered to the site.

When instructed by the Engineer, the Contractor shall also provide a sample of any replacement batch of paint.

Unless permitted by the Engineer, painting, except for procedure trials, shall not start until the Engineer confirms that the samples are satisfactory.

In addition the Contractor shall provide 500 ml samples for application control purposes when instructed by the Engineer and only under his supervision.

The Contractor shall provide 500 ml tins with lids for the samples at the start of painting or before any procedure trials. The quantity of containers supplied shall be sufficient to avoid any delay in taking samples throughout that work.

(7) Application of Paint

At least 7 days in advance of the commencement of painting operations, the Contractor shall submit his proposed programme of painting operations to the Engineer for his approval.

The Contractor shall also supply details of the overall wet film thickness of each coat to be applied and of the coverage rates, in m^2,/litre, for each coat of paint to be used in the works.

The calculations shall be based on the volume solids plus an allowance for surface roughness, uneven application and wastage.

Prior to the commencement of painting on any coat, the Contractor shall carry out painting procedure trials, in the presence of the Engineer, on a suitably prepared surface up to 10 square metres or as agreed with the Engineer, employing the paint, labour and equipment to be used in the works.

The Contractor shall demonstrate his ability to apply the paint in accordance with the Specification and manufacturers recommendations and shall obtain the Engineer's approval to commence the application of a particular coat before starting.

All paints shall be prepared and applied in strict accordance with the manufacturers instructions and no thinners or cleaners shall be employed other than those recommended by the manufacturer.

The Contractor shall execute the works only when the conditions at the site, including temperature and humidity, are suitable for applying the paint to be used and ensure that the structure to be painted is fully accessible to the Contractor and to the Engineer for inspection prior to, during and after painting operations.

Paint shall not be applied:

(i) When the relative humidity rises above 90%.

(ii) When the ambient temperature falls below 4°C.

(iii) During rain, fog, mist or in a dust laden atmosphere.

(iv) When the amount of moisture on the surface to be painted, or that likely to be caused by subsequent condensation or rain may, in the opinion of the Engineer, have a harmful effect on the paint.

(v) After 6.00 p.m. and before 6.00 a.m.

(vi) Without the approval of the Engineer.

(vii) When wind borne dust may have a harmful effect on the paint.

Paint shall be applied to surfaces, which have been prepared and cleaned in accordance with the Specification and approved for painting in advance by the Engineer.

It shall be the Contractor's responsibility to seek and obtain such approval prior to commencing painting operations. Where such approval is not obtained, the affected area of painted surface shall not be approved for payment. The Contractor shall be responsible for restoring the affected surface to the specified condition required for the application of the required paint coat at his own expense.

A coat of paint in a system shall be applied by brush only unless otherwise approved in advance by the Engineer.

Mixing of paints shall be carried out by mechanical mixers. Prior to application, the paint shall be mixed a sufficient period to thoroughly mix the pigment and shall be kept thoroughly mixed during its application.

Wet film thickness gauges shall be used where practicable to check that the wet film thickness for each coat is not less than:

$$\frac{\text{Minimum dry film thickness (mdft) x 100}}{\text{Volume solids \%}}$$

During the application of a paint system, the Contractor shall ensure that the progressive total thickness of the applied coats shall allow the specified minimum total DFT to be attained without exceeding overall the proposed wet film thickness by more than 20%. The local dry film thickness for the primer shall not exceed the specified minimum dry film thickness by ore than 30% and for other paints by more than 75%.

Painting shall be carried out in a neat and workmanlike manner, in accordance with the approved programme.

Surfaces to be painted shall be free from moisture, dust, grease or any other deleterious materials that would prevent the bond of the succeeding application.

Each coat of the specified paint system shall be generally free from surface defects, including cratering, pin-holing, blistering, rivalling, sagging, bittiness, dry spray and cissing, as defined in BS 2015 "Glossary of Paint Terms". Any deficiencies in the applied coat shall be rectified to the satisfaction of the Engineer before the application of a subsequent coat. The finished system shall have an even and uniform appearance.

Unless otherwise agreed with the Engineer, 1 no. Stripe Coat shall be applied over all welds and fasteners including washers and to all external corners excepting those of RHS members. The stripe coat shall be applied over the primer.

Exposure Time for prepared steel surfaces and over-coating times for paints shall be as follows:

(i) Clean steel prepared by blast cleaning or bright steel prepared by abrading or grinding shall be primed within 4 hours.

(ii) Primed surfaces shall have the following coat applied within 7 days or as recommended by the paint manufacturer.

(iii) Subsequent coats shall be applied within 14 days or such lesser time as recommended by the paint manufacturer.

(8) Protection Against damage

The Contractor shall make all necessary provisions to prevent damage to completed coats of paint and to other property from all cleaning, painting, protection, inspection or other operations.

Paint, stains or damage to surfaces not specified for painting shall be removed or rectified to the satisfaction of the Engineer at the Contractor's expense.

All painted surfaces that are failed, marred or damaged as a result of operations of the Contractor shall be repaired by the Contractor, at his expense, with materials and to a condition equal to that of the coating(s) damaged and utilising a restorative method approved by the Engineer.

Where traffic causes an objectionable amount of dust in the atmosphere during painting operations the Contractor shall, where directed by the Engineer, water the offending road surface and shoulders for a sufficient distance at, and on each side of, the location where painting is being carried out, at his own expense.

(9) Inspection

A specialist shall be appointed by the Engineer where needed to ensure that the works are carried out by the Contractor in accordance with the

Specifications and relevant contract documents and to approve completed work for payment by the Engineer.

The Contractor shall be required to provide all facilities and assistance necessary to enable the specialist to safely reach all parts of the bridge structure for inspecting, measuring or approving the Contractor's operations at all reasonable times. Instruments to be provided by the Contractor shall include:

2 no. Inlet/Dry Hydrometers
2 no. Sets Wet Film Gauges
2 no. Elcometers to measure dry film thickness

2714. PROTECTION OF STEEL STRUCTURES AGAINST CORROSION

(1) General

The operations described in this Clause include the application of protective grease and oil based systems to miscellaneous structural elements.

(2) Protective Systems for Suspension Cables and Hangers

Protective systems include grease and felt systems, grease packing and oil systems.

(3) Protective Systems for Suspension Cables and Hangers

The Contractor shall use the protective system as described in this Clause for the existing suspension cables and hangers.

The protective system to the suspension cables and hangers shall include the removal of existing protective system, either in whole or in part as indicated in the contract, the preparation of the surfaces of the steel ropes, and the application of the new protection system.

The Protective System to be applied shall comprise:

(a) The application of a coating of ordinary neutral grease of any reputed make.

(b) A tar-felt sheet cover. The cover shall be fixed to prevent the entry of water and shall be continuous spirally lapped in a method approved by the Engineer.

The surfaces of the wire ropes shall be prepared by removing existing cover in whole or in part as indicated in the contract, then cleaning the exposed surface of the wire ropes to remove dirt, hardened grease and surface rust.

Broken or rusted wires and other damages shall be brought to the attention of the Engineer before any further work is carried out on the affected area.

The finished prepared surfaces shall be free of contamination detrimental to subsequent application of grease and cover to the satisfaction of the Engineer. The surface shall be free from dust and grit and be dry and ready for greasing. Surface preparation shall be continued until the specified standard of surface finish has been achieved.

(4) Protective System for Bearings, Inside Cable Saddles, Hanger Saddles and Hanger Sockets

The protective system shall include the removal of existing protective system, cleaning of dirt and contaminants and the application of the new protection system.

The Protection System to be applied shall comprise the application of a coating of ordinary neutral grease of any reputed make.

The finished prepared surfaces shall be free of contamination detrimental to subsequent application of grease to the satisfaction of the Engineer. The surface shall be free from dust and grit and be dry and ready for greasing. Surface preparation shall be continued until the specified standard of surface finish has been achieved.

Oil of an approved make shall be applied to all pins of top and bottom hangers and bridge bearings. Cracks around any pins or bearing or plates shall be brought to the attention of the Engineer before any further work is carried out on the affected area.

(5) Repair of Damaged Areas

The Contractor shall make good any damage to the original protective system arising from his execution of the works.

2715. REPAIR OF STEEL BEARINGS

(1) Resetting and Repositioning of Bearings

(a) General

The work on the steel bearings comprises the repositioning of the free roller bearings and the re-setting of the fixed bearings in the Bridges. In the course of these operations jacking up of the bridge shall be required to the method as provided or as directed by the Engineer. To re-set the fixed bearings at their correct vertical load, additional jacking operations shall be necessary at the free bearing location to determine the magnitude of the vertical load.

The Contractor shall make available to the Engineer the necessary access and equipment for him to check, monitor and take measurements throughout the jacking operations.

(b) Release of Existing Connections

No existing connections shall be released without the prior approval of the Engineer. Tightening, removal or replacement of bolts shall be In accordance with the written methods provided by the Engineer.

(c) Bedding of Mechanical Roller Bearings on Concrete Piers

When re-setting an existing roller bearing the following shall apply:

- Any existing bedding material and packing shims remaining beneath the bearing base plate positions shall be removed by a method approved by the Engineer. The Contractor shall exercise all due care in preparing the bedding for bearings to avoid any damage to the structure.

- Any oil or grease on the plinth where bearings are to be re-set shall be removed with an approved de-greasing compound which shall then be rinsed off with clean water. All loose particles of concrete, rust, any dust on the plinths shall be removed by suction or by using a properly filtered oil-free airline.

(2) Bedding Mortar for Resetting of Bearings

(a) General

Bedding mortar shall satisfy the following performance requirements:

(i) It shall have a compressive strength not less than 60 N/mm^2

(ii) The flow characteristics shall be such that the volume as specified in the contract is completely filled with a homogeneous material when placed within the range of ambient temperature between 5°C and 25° or as otherwise directed by the Engineer.

(iii) The physical and chemical properties shall be compatible with those of all adjoining surfaces.

Bedding mortar shall at no time be subjected to a loading, which will induce a compressive stress exceeding 15 N/mm^2 or 0.25 of its compressive strength at the time of loading.

(b) Material

(i) The maximum aggregate size in flowable bedding mortars shall not exceed one quarter of the minimum bedding thickness.

(ii) Proprietary materials shall be stored as follows:

- The material shall be stored in a dry environment at a temperature of not less than 10°C.
- The containers shall be damp proof, leak proof and easy to empty of their contents.
- Containers shall be marked with the batch reference number, component identification, manufacturer's name, net weight and such warnings or precautions concerning the contents as are required.
- The material shall not be removed from the store unless immediately required for mixing and use in the works.
- Material shall not be used after six month from the date of manufacture or after the period specified by the manufacturer or supplier.
- The Contractor shall supply with each batch or part of a batch of the material delivered to the Site, certificates furnished by the supplier or manufacturer stating the following:

  - Manufacturer’s name and address.
  - Manufacturer's agent's name and address where applicable.
  - Description of material and brand name.
  - Batch reference number, size of batch, number of containers in the delivery order.
  - Date of manufacture.
  - The chloride ion content, expressed as a percentage by mass of the material.

- Calcium chloride or admixtures containing chloride salts more than 0.2% of the mass of cement shall not be used.
- Ordinary Portland Cement shall comply with 18:269.
- The weight of soluble alkali in the mix expressed as equivalent sodium oxide shall be limited unless the aggregate is shown to be non-reactive.
- Resinous bedding mortars shall be based on thermosetting organic polymers consisting of stable fluid and/or solid components, which on mixing react chemically to form a hardened solid mass. Products shall be formulated from

epoxide polyester, polyurethane or acrylic resin system such other formulation as is approved by the Engineer.

- Fillers or aggregates to be incorporated in accordance with the manufacturer's recommendations, to extend or modify the properties of the resinous composition, shall be pre-bagged, dry and factory proportioned. The addition of other fillers or aggregates shall not be permitted.

(3) Site Mixing, Placing and Curing

(i) Mixing placing and curing of proprietary bedding mortar shall be carried out in accordance with the manufacturer's written instructions together with the following:

- The material shall not be mixed or placed in the Works at ambient temperatures of less than 5°C. If for 24 hours before, during or after placing, the ambient temperature falls below 5°C the Contractor shall maintain the temperature of the sub-strate and other adjoining surfaced at not less than 5°C for the duration of the curing period recommended by the manufacturer.
- For cementitious mortars the water cement ratio shall not exceed 0.35. The water content shall be determined during the approval tests, and maintained within ±2 per cent of the quantity approved by the Engineer in mortars placed in the Works.
- At ambient temperatures of less than 10°C the temperature of the mixing water shall be not less than 20°C nor more than 25°C.

(ii) For cementitious bedding mortars, the sub-strate shall be flushed clean with water two hours before placing and maintained wet until placing commences.

Any free standing water on the surface of the sub-strate shall be removed before placing the mortar. The underside of the base plate shall be clean and free from loose rust and loose mill scale at the time of bedding.

- Immediately after placing the mortar shall be protected to prevent evaporation for at least three days.
- The mortar shall be placed in its final position within 20 minutes of its discharge from the mixer.

(iii) For resinous bedding mortars the sub-strate shall be dry, free from loose dirt and dust and shall meet the conditions specified by the manufacturer. The underside of the base plate shall be clean and free from loose rust and loose mill scale at the time of bedding.

- The mortar shall be placed in its final position within one hour from its time of discharge from the mixer or lesser period as specified by the manufacturer.
- Only full packs of mortar or sub-packs as presented by the supplier shall be mixed On-site proportioning shall not be permitted.

(iv) When the proportions have been approved by the Engineer no variations shall be made in the manufacture, supply, mix proportions or method of mixing of the material without the consent of the Engineer.

(v) No internal metal shims shall be allowed to remain in the hardened bedding mortar except where described in the contract.

(4) Approval Tests

(i) Mortar shall not be used in the Works until it has been approved by the Engineer. The Contractor shall provide the Engineer with copies of the manufacturer's Specification.

(ii) Flow Test Between Surfaces

- The mortar for each flow test shall be batched in one load strictly according to the manufacturer's instructions.
- Flow tests shall be conducted between concrete and a rusty steel plate at ambient temperature of 5°C. The flow characteristics shall be assessed with the rusty steel plate on top, and with the pre-cast concrete slab on the bottom. The surface of the concrete slab shall be washed thoroughly with water and all traces of surface water removed.
- The size of the test apparatus is to represent the actual site condition. The mortar shall be poured in one corner of the apparatus until the level of the mortar has reached at least 10 mm above the underside of the top plate. After 24 hours the top plate shall be removed and the exposed surface lightly brushed with a stiff bristle brush to remove any surface skin which may be covering voids. The bedding mortar formed shall be free from significant voids, cracks and other defects, at both 5°C and 20°C.
- If difficulty is experienced in achieving a satisfactory flow for cementitious mortars the water content of the mix shall be adjusted and the test described above repeated. The mortar shall be rejected if further adjustments of the water content do not produce an acceptable result

(iii) Compressive strength tests for cem1entitious bedding mortars shall be carried out on the 100 mm cubes prepared, cast and cured at temperatures given in Table 27.3. The mortar used for strength tests and all subsequent testing shall have the same water content, as determined from the flow tests and approved by the Engineer. There shall be no compaction.

Table 27.3 : Test Temperatures and Strength (Cementitious Bedding Mortar)

Cementitious Bedding Mortar Ambient Test Temperature of 20° C	
Mixing water temperature	20° C
Mixer and mould temperature	20° C
Dry mortar material temperature	20° C
Curing temperature	20° C
Minimum 28 days compressive	60 N/mm^2

(iv) Compressive strength tests for resinous bedding mortars shall comply with BS 6319: Part 2 and shall be carried out on six 40 mm cubes as shown in Table 27.4.

Table 27.4 : Test Temperatures and Strength (Resinous Bedding Mortar)

Resinous Bedding Mortar Ambient Test Temperature of 20° C	
Mixer and mould temperature	20° C
Mortar material before mixing	20° C
Curing temperature	20° C
12 hour} 24 hour } min. compressive strength 72 hour}	30 N/mm^2 50 N/mm^2 60 N/mm^2

2716. MEASUREMENT

The Measurement for minor repairs of defective concrete shall be made in cubic meters. Measurement for replacement concrete shall be made in cubic meters. Measurement for sealing cracks and injection shall be made by weight (in kg) of epoxy consumed for grouting. Provision of nipples required for grouting shall be measured in numbers.

Measurement of sealing of cracks and injection shall be made by weight of cement consumed. in kg for cement grouting. Measurement for application of epoxy mortar for specified thickness shall be made in square meters. Measurement for bonding of old and new concrete by epoxy mortar shall be made in square meters.

Measurement for guniting/shotcreting shall be made in square meters. Measurement for repair/replacement of bearings shall be made in number. Measurement for dismantling of concrete wearing coat shall be made in square meter of the area of wearing coat dismantled. Measurement for painting shall be made in square meters. Measurement for protection against corrosion shall be on lump basis.

2717. PAYMENT

The quantities measured as provided above shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112.

SECTION 2800 – ENGINEERING WORKS

SECTION 2800 –ENGINEERING WORKS

2801. SCOPE

This Section covers all component of bio-engineering works such as provision of seed and plant cutting, nursery construction and operation, slope preparation for planning, site planting and sowing, jute netting, gabion wire bolsters and wire bolsters and wire netting, site protection and aftercare/maintenance.

2802. PROVISION OF SEEDS

The Contractor shall provide or collect seeds of the required species and quantities in accordance with the requirements described hereafter, as and when required. He shall supply all necessary expertise, resources and facilities to ensure that these requirements are met in full. It shall be ensured that the seed is of a high quality.

The Engineer shall give indications as to the expected amounts of seeds required and the time of availability. But it shall be the Contractor responsibility to ensure that adequate quantities of seeds are obtained in a timely manner.

The weight to be specified shall be for sun-dried seeds separated completely from fruiting bodies and other unwanted parts, and ready for storage and subsequent sowing. There is usually large discrepancy between this weight and that of the freshly collected, untreated fruits.

Should the Contractor be unable to supply the specified seeds, the advice of the Engineer should be sought. The Engineer may approve other substitute species, if found appropriate. Seed shall not be obtained commercially without the Engineer's written authority.

(1) Grass Seed Collection

(a) The species of grass seeds to be collected shall be determined by the Engineer. The Contractor shall be responsible for determining seed sources, through these may be specified by the Engineer's instructions. Seeds shall be collected in or very close to the office of use or the project area as much as possible.

(b) If the Engineer does not specify the species, then the current approved list of bio-engineering plants, as determined by the Geo-Environmental Unit of the Department of Roads shall be referred to.

(c) Seeds shall be collected from as many individual plants as possible. Seeds shall be collected from the largest and most vigorous plants.

(d) The Contractor shall under no circumstances damages or remove the roots of grass plants while collecting seed. The Contractor shall be

responsible for safety measures and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the collection of seeds.

(e) Seeds shall only be collected when fully ripe. Seeds collected early shall not be accepted. The Contractor shall be held liable if the germination rate of seeds is lower than 70%.

(f) Immediately after collection, seeds shall be separated from flower heads by the method normally used by farmers for other grasses. Once separated, the seeds shall be sun-dried before storage.

(g) Seeds shall be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers shall be raised above the floor. They shall not be kept in the same building in which materials like cement, or any chemicals, fuels or lubricants are stored. Grass shall be stored in bags made of cotton. Seeds shall be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation, or pest attack. Seeds shall only be stored after they have been properly dried in the sun beforehand.

(h) Measurement and Payment: Works shall be measured on the basis of actual quantity collected, weighed in Kilogram and accepted by the Engineer. The quantities thus measured shall be paid at the unit rates shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for making arrangements of collection location, provision of safety measures, collection of seeds, separation of seeds, preparation of seeds, sun drying, packing and providing the seeds as per these Specifications.

(2) Tree and Shrub Seed Collection

(a) The species of tree and shrub to be collected shall be determined by the Engineer. The Contractor shall be responsible for determining seed sources, though these may be specified by the Engineer's instructions. Seeds shall normally be collected in or very close to the working area.

(b) If the Engineer does not specify the species, then the current approved list of bio-engineering plant, as determined by the Geo-Environmental Unit of Department of Roads shall be referred to.

(c) Seeds shall be collected from as many individual plants as possible. If any event, they shall be collected from at least ten individual plant. The plants from which the seeds are collected shall show vigorous growth and good form. Mis-shaven and stunted plants shall be discarded.

(d) The Contractor shall under no circumstances damage plants while collecting seed. The Contractor shall be responsible for making all necessary arrangements with and owners, farmers and the local District Forest Office, as applicable, before the collection of seeds.

(e) Appropriately trained personnel with appropriate equipment shall be employed while collecting the seeds. It shall be the Contractor's responsibility to ensure safe working conditions for his employees or Sub-contractors.

(f) Seeds shall only be collected when fully ripe. Seeds collected early shall not be accepted. The Contractor shall be held liable if the germination rate of seeds is lower than 80%.

(g) Immediately after collection, seeds shall be separated from fruit by the method normally used by farmers and foresters for this purpose; this shall depend on the individual species. Once separated, the seeds shall be sun-dried before storage.

(h) Seeds shall be stored in a cool, dry, ventilated building with adequate precautions taken against pests. Containers shall be raised above the floor. They shall not be kept in the same building in which materials like cement, or any chemicals, fuels or lubricants are stored. If kept in sealed containers, the seeds shall be carefully inspected on a weekly basis to ensure that there is no deterioration or mould formation or pest attack. Seeds shall only be stored after they have been properly dried in the sun beforehand.

(i) Measurement and payment: works shall be measured on the basis of actual quantity collected, accepted and weighed in Kilogram. The quantities thus measured shall be paid at the unit rates shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for making arrangements of collection location, provision of safety measures, collection of seeds, separation of seeds, preparation of seeds, sun drying, packing and providing the seeds as per these Specifications.

2803. PROVISION OF PLANT CUTTINGS

Species of plants to be collected for vegetative propagation shall be determined by the Engineer. The Contractor shall be responsible for determining plant material sources, through these may be specified by the Engineer's instructions. Plants shall normally be collected in or very close to the working area.

If the Engineer does not specify the species, then the current approved list to bio-engineering plants, as determined by the Geo-Environmental Unit of the Department of Roads shall be referred to.

(1) Provision of Grass Cutting

(a) Cuttings of various types shall be taken from grass species, which are known to propagate.

(b) Cuttings shall be made from as many healthy individual plants as possible. The plants from which the cuttings are taken shall show vigorous growth and good form. Grass clumps showing stunted growth shall not be considered as sources.

(c) Apart from the clumps, which are dugs up to make cutting, the contractor shall under no circumstances damage other plants. The Contractor shall be responsible for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable before the making of hardwood cuttings.

(d) The type of cuttings to be made shall depend on the species and shall be as shown in Table 28.1. If the species used is not listed here, then the latest technical information provided by the Geo-Environmental Unit shall be consulted. If the species is still not covered, then stem and root slip cuttings shall be used.

Table 28.1: Type of Grass Cutting

Local name	Botanical Name	Best Propagation	Details
Amliso	Thysanolaena maxima	Rhizome cutting	Stem: 100-150 mm; rhizome: 50-80 mm
Babiyo	Eulaliopsis binata	Slip cutting	Stem: 100-150 mm; root: 20-40 mm
Dhonde	Neyraudia reynaudiana	Rhizome/stem cutting	Rhizome cutting:- Stem: 100-150 mm; rhizome: 40-50 mm Stem cuttings: 2 nodes plus 20 mm each sides
Kans	Sacccharum spontaneum	Slip cutting	Stem: 100-150 mm; root: 30-40 mm
Khar	Cymonpogon microtheca	Slip cutting	Stem: 100-150 mm; root: 30-40 mm
Khus	Vetiver lowsonil	Slip cutting	Stem: 100-150 mm; root: 30-40 mm
Napier	Pennisetum purpureum	Stem cutting	Single node:- 1 node with 30-40 mm top and 100-150 mm bottom; Double nodes:- 2 nodes plus 30-40 mm each sides
Narkat	Aruundo clonax	Stem/Slip cutting	Single cutting:- 2 node plus 30-40 mm each sides Slips cuttings:- Stem: 100-150 mm; root:30-40 mm each sides

Padang bans	Himalayacalamus hookerianus	Rhizome	Stem:750-1200 mm; rhizome: 100-200 mm.
Phurke	Arunduella nepalensis	Rhizome cutting	Stem:100-150 mm; rhizome: 30-40 mm.
Sito	Neyraudia arundinacea	Rhizome cutting	Stem:100-150 mm; rhizome: 30-60 mm.
Tite nigalo	Drepanostachyum intermedium	Rhizome	Stem:50-1200 mm; rhizome: 100-200 mm.

(e) Where roots are required for the cuttings, grass clumps shall be carefully dug up. They shall not be pulled hard so as to damage the material. They shall be separated carefully by hand, using a sharp khukuri or knife where necessary. There shall be no tearing of the plant fabric.

(f) Stem cutting shall be made using sharp secateurs or khukuri. The tip cut shall be made at right angles to the stem and the bottom cut shall be made at 45^{o} C to the stem.

(g) Once cuttings have been made, they shall be wrapped in wet hessian jute immediately. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet hessian between all operations such as digging out of the ground, splitting out, trimming and planting. If the hessian jute is not easily available, the cuttings shall be covered with the thick blanket of off-cut part of vegetation such as Titepati and Banmara. For this prior approval of the Engineer shall be required. Under any circumstances, all cuttings shall be planted the same day that they are made.

(h) Measurement and Payment: Measurement of grass cuttings shall be made on the basis of actual numbers of slip or cutting prepared, counted on site and accepted. The quantities thus measured shall be paid at the unit rate shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for all arrangements for uprooting of grass clumps, collection of materials for cuttings and preparation and providing the cuttings as per these Specifications.

(2) Provision

(a) Hardwood cuttings shall be taken from shrubs and trees species which are known to propagate easily by vegetative means.

(b) Cuttings shall be made from as many healthy individual plants as possible. The plants from which the cuttings are taken shall show vigorous growth and good form. Mis- shaven and stunted plants shall not be considered as source.

(c) Apart from the branches from which cuttings are taken, the Contractor shall under no circumstances damage plants while taking cuttings. The Contractor shall be responsible for taking safety precautions and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before the making of hardwood cuttings.

(d) Hardwood cuttings shall be made from stems which are between 6 and 18 months old. Materials outside this range shall not be used. The Contractor shall be held liable if the success rate of cuttings is lower than 70%.

(e) Hardwood cutting shall be made using sharp secateurs or a sharp saw. The top cut shall be made at right angles to the stem and the bottom cut shall be made at 45° to the stem. Under no circumstances shall there be any damage to the bark of the cutting.

(f) Hardwood cuttings, which are to be planted in the nursery for later multiplication, shall be normally 150 to 200 mm in length and 20 to 30 mm in diameter. This size shall not be exceeded for the majority of species unless specified or approved by the Engineer.

(g) Hardwood cuttings which are to be used in brush layering, palisades and live stakes shall normally be 450 mm for brush layering on road embankments, 600 mm for brush layering on landslide debris, 600 mm for palisades and 20 to 40 mm in diameter. This length of cuttings shall not be exceeded for the majority of species unless specified or approved by the Engineer.

(h) The size of cuttings shall be of a minimum length of 1000 mm and 50 mm of diameter for fascines. All the small branches growing from the main branch shall be preserved. Those small branches contain the first sprouting buds which will help to keep alive the main branches as they are buried in the ground.

(i) A number of species can be propagated using large truncheon cuttings. In this category fall chuletro (Brassaiopsis hainla), dabdabe (Garuga pinnata), kavro (Ficus lacor), phaledo (Erythrina species) and Gliricidia sepium. Hardwood cuttings for these species shall be in the range of 2000 to 2500 mm in length and 50 to 80 mm in diameter unless otherwise specified.

(j) All trunchen cuttings shall be covered with long mulch during transportation and storage. Under any circumstances, all cuttings shall be planted within two days that they are made.

(k) Measurement and Payment: Measurement of hardwood cuttings shall be made on the basis of actual numbers of cutting prepared, counted on site and accepted. The quantities thus measured shall be paid at the

unit rate shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for all arrangements for collection of materials and preparation of cuttings and providing the cuttings as per the Specifications.

(3) Provision of Bamboo Cutting

(a) Bamboo cuttings shall be propagated by two different methods i.e traditional method and single node culm cuttings method.

(b) Cuttings shall be made from as many healthy individual culm as possible. The culm from which the cuttings are taken shall show vigorous growth and good form having heavily branched. Mis-shaven and stunted plants shall not be considered as source.

(c) The Contractor shall be responsible for taking safety precautions and for making all necessary arrangements with landowners, farmers and the local District Forest Office, as applicable, before making of cuttings. The traditional method which will require to take the whole culm and mother rhizome may eradicate the further development of clump. In this case, the contractor shall be responsible to make aware of such probability to the owner before taking the rhizomes from such clump. However, if the sourcing clumps are growing on steep slopes, the contractor shall not take more than 10% culm from the sourcing clump.

(d) The type of cuttings to be made which depend on the species shall be as shown in Table 28.2. Single node culm cuttings or traditional rhizome cuttings shall be made from the culm which are between 2-3 years old. Materials outside this range shall not be used without the prior approval of the Engineer. The Contractor shall be held liable if the success rate of single node culm cuttings is lower than 60% and in the case of or rhizome cuttings not surviving 100%.

(e) Single node cuttings shall be made using sharp log saw. The top and bottom cut shall be made at right angles to the stem. Under no circumstances shall there be any damage to the bud and internode section of culm.

(f) The rhizome cuttings shall be made using sharp log saw, axe and secateurs.

(g) Once cuttings have been made, they shall be wrapped in wet hessian jute immediately. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet hessian between all operations such as taking from the parent plant, transporting and planting. Under any circumstances, all cuttings must be planted within two days of that they are made.

(h) Measurement and Payment: Measurement of bamboo cuttings shall be made on the basis of actual numbers of cuttings prepared, counted on site and accepted. The quantities thus measured shall be paid at the unit rate shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for all arrangements for purchasing of bamboo and preparation of cuttings and providing the cuttings as per the Specifications.

Table 28.2: Types of Bamboo Cutting

Local name	Botanical Name	Best Propagation	Details
Choya/tama bans	Dendrocalamus hemiltonil	Single Node culm/ rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm.
Dhanu bans	Bambusa balcooa	Single Node culm/ rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Kalo bans	Dendrocalamus hookeri	Single node culm/ rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Mal bans	Bambusa nutans	Single node culm/ rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Malingo bans	Arundinaria maling	Rhizome cutting	Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Nibha/gopi bans	Ampelocalamus pattellaris	Single node culm/ rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight

			and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Nigalo bans	Phyllostrachys	Rhizome cutting	Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Parayana bans	Drepanoschyum hookerieanum	Rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm
Tharu bans	Bambusa tulda	Single node culm/ rhizome cutting	Single node culm cuttings:- 1 node and 150 mm of each side, straight and fine cut, main branch should be 200-300 mm long; Rhizome cuttings:- Culm 2500-3000 mm length, leave all branches with no leaf (manually flushed); rhizome: 300-500 mm

2804. NURSERY CONSTRUCTION

The Contractor shall provide nurseries to contribute stocks of grasses, shrubs and trees for planting operations as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required by the Engineer. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

The Contractor shall note that the establishment and effective operation of plant nurseries is a skilled business requiring experienced and trained staff. These specifications alone do not provide all the information needed to set up and run nurseries. The Contractor shall seek the advice of specialist agencies and shall refer to the large number of reference books available on the subject.

The purpose of a nursery shall be to supply good quality, healthy plants of the correct type and species at the precise time they are required.

(1) Nursery Establishment

(a) The Contractor shall provide nursery facilities adequat9 to supply all of the stock required for planting operations. Alternatively, he may

procure planting stock from elsewhere at the time of site planting, provided it is of a standard acceptable to the Engineer and as described hereunder.

(b) In selecting a site for a nursery, if not instructed by the Engineer, the Contractor shall fulfil the following requirements.

(i) Nurseries shall be as close as possible to all sites to be planted. They shall be at the same altitude as, and in an identical climatic area to, the sites to be planted.

(ii) Wherever possible, nurseries shall be established on land owned by the Department of Roads if it is available and biophysically suitable. If it is not, other land of His Majesty's Government shall be used if it is available.

(iii) Nurseries shall have a reliable and adequate supply of water which remains constant throughout the later part of the dry season.

(iv) Nurseries shall have all weather vehicular access.

(v) Nurseries shall have a perimeter of stock-proof fencing, effective against all domestic animals.

(vi) Nurseries shall have a weather- and pest-proof office cum seed store and proper storage facilities for seed. Seed shall be kept cool, dry and in sealed containers, as-specified in Sub-clauses 2802 (1) and 2802 (2).

(vii) All nurseries shall be provided with at least two above-ground compost bays, built of stone, brick or timber.

(viii) Where a nursery is established on a slope exceeding 2°, the ground shall be leveled by terracing before beds are constructed.

(ix) A constant staff of qualified and experienced people must be provided.

(x) There shall be adequate space in each nursery location for all operations to be performed in the cycle of work. In particular, all plants shall be spaced out periodically as they grow and there shall be adequate bed area to accommodate them.

(2) Construction of Nursery Beds

(a) Nursery .beds shall be made in a different way according to their purpose. The Contractor shall ensure that there are adequate beds available for all the operations to be undertaken in the nursery.

(b) There shall be paths around all beds to ensure the best possible access for operations such as weeding and watering.

(c) Table 28.3 summarises the construction details of the five main bed types, which are described in full in paragraphs (d) to (h).

Table 28.3: Construction Details of Nursery Beds

Bed type	Bed size	Details of construction
Bed for grass seeding, grass slips propagation	Bottom width 1200 mm and top width 1000 mm x 200 mm high	Bottom of the bed should be compacted making a camber to facilitate the drainage; 50 mm washed gravel placed above the ground; then 50 mm of 1:1 mix of soil and compost; and topped with 100 mm of 3:1 mix of seived forest topsoil and washed sand.
Beds for bare root tree seedlings.	Bottom width 1200 mm and top width 1000 mm x 200 mm high	Bottom of the bed should be compacted making a camber to facilitate the drainage; 50 mm washed gravel placed above the ground; then 50 mm of 1:1 mix of soil and compost; and topped with 100 mm of 3:1 mix of seived forest topsoil and washed sand.
Seed beds for tree/shrub seedling.	1000 mm wide (external), 170 mm high with edging; Shade 900 mm of height on the lower side and 1200 mm higher side.	Bed should be provide with brick, flat stone or plank edging as determined by the Engineer; shade should be provided of waterproof materials or as determined by the Engineer; 50 mm of washed gravel placed above the compacted and cambered ground; then 50 mm unseived forest soil 50 mm of 1:3 mix of sieved forest soil and washed sand; and topped with 20 mm of washed, sieved and sterilized sand.
Stand out beds for tree/shrub seedlings.	1000 mm wide (external), 170 mm high with edging; Shade 900 mm of height on the lower side and 1200 mm higher side.	Bed should be provide with brick, flat stone or plank edging as determined by the Engineer; shade should be provided of waterproof materials or as determined by the Engineer; 50 mm of washed gravel placed above the compacted and cambered ground.
Beds for the propagation of bamboo culm cutting and stool bed for tree and shrub cutting	Bottom width 1200 mm and top width 1000 mm x 200 mm high	Ground below the bed is dug to a depth of 300 mm. Bed is made with 100 mm of unseived soil (lower) and 200 mm of sieved soil (upper). A bund of 100 mm high is formed around the edge. 1500 mm high shade of bamboo frame jute is made.

(d) Grass beds shall be constructed to hold grass seeds, grasses being propagated by vegetative means. These can be of any practical length but shall be flat and of 1200 mm base width and 1000 mm of top width on compacted and a cambered ground. They shall rise to a height of 200 mm above the surrounding ground. They shall be made up as follows: 50 mm of washed gravel is placed above the ground; then 50 mm of 1:1 mix of soil and compost; and the bed is topped with 100 mm of 3:1 mix of fertile, loamy forest topsoil and washed sand. All sieving shall be done with a mesh size of 2 mm or smaller.

(e) Bare root beds shall be constructed to hold seedlings transplanted from the seed beds. These can be of any practical length but shall be flat and of 1200 mm base width and 1000 mm of top width on compacted and a cambered ground. They shall rise to a height of 200 mm above the surrounding ground. They shall be made up as follows: 50 mm of washed gravel is placed above the ground; then 50 mm of 1:1 mix of soil and compost; and the bed is topped with 150 mm of 3:1 mix of fertile, loamy forest topsoil and washed sand. All sieving shall be done with a mesh size of 2 mm or smaller.

(f) Seed beds shall be made very carefully for germinating small seeds of shrubs and trees. These can be of any practical length but shall be flat and of one metre in width on compacted and a cambered ground. They shall rise to a height of 170 mm above the surrounding ground and provided with shadings as per the details given in the following paragraph (i). They shall be made up as follows: 50 mm of washed gravel placed on the ground; then 50 mm of unsieved forest soil; 50 mm of 1:3 mix of forest soil and washed sand; and the bed is topped with 20 mm of washed, and sterilised sand. All sieving shall be done with a mesh size of 2 mm.

(g) Standout beds shall be constructed to hold seedlings in polythene pots. These can be of any practical length but shall be flat and of one metre width. Bed floors shall be above surrounding ground level and they shall have a 50 mm layer of washed gravel on the compacted and cambered ground. They shall have a surround, preferably made from flat stones, plank or bricks. The bed shall then be covered with the highly porous shadings as per the details provided in the following paragraph (i).

(h) Beds for the propagation of bamboo culm cuttings and stool cuttings of trees and shrubs, shall be made specially. These can be of any practical length but shall be flat and of 1000 mm width at top and 1200 mm width at bottom. They shall rise to a height of 300 mm above the surrounding ground. They shall be made up as follows: the ground below the bed is dug to a depth of 300 mm; the bed itself is then made with 100 mm of unsieved soil on the original surface, and 200 mm of soil above this. All soil sieving shall be done with a mesh size of 2

mm or smaller. Finally, a bund of 100 mm high shall be formed around the edge.

(i) Shades shall be constructed over the beds and kept in position over delicate seedlings during hours of intense sunlight, according to need. Shades shall be 900 to 1200 mm above the ground, and angled so as to be effective for as much of the day as possible (ie with the lower side to the south). Bamboo strips laced together with nylon string are particularly suitable in most cases; but over tree and shrub seed beds, thatched shades with a polythene lining shall be used.

(3) Measurement and Payment: Work to be measured shall be the actual top area in sq.m of beds constructed on site and accepted. Only the finished area of the beds shall be considered after the completion of its shades. However, despite the fact that shades will be covering larger area than the beds, the final measurement shall be governed by the area of the top of the bed for payment. The payment shall be the full and the final compensation to the Contractor for providing all materials to be incorporated, ail labour, tools, equipment and incidentals to complete the works of Nursery establishment and construction of Nursery beds as per these Specifications.

2805. NURSERY OPERATION AND MANAGEMENT

(a) The contractor shall operate the nursery according to a high standard. The nursery shall be staffed well tended at all times. It shall be maintained in clean, tidy and efficient manner at all times. Plants shall always be healthy and vigorous.

(b) Due to the nature of bio-engineering works, nurseries shall normally be operated and managed by small local contractors with a range of agricultural skills provided it is specified in the Contract. If provided in the Contract, nurseries may also be operated and managed by direct employees of the Division Road Office.

(c) Plants shall be kept properly weeded at all times.

(d) Watering, as required for good plant growth, shall be carried out regularly in the cool of the evening between sunset and dusk. The Contractor shall ensure that the soil in all beds is kept moist but not saturated at all times. Beds shall be kept moist even when empty, so that the soil is kept in good condition.

(e) The timing of nursery operations shall be of the utmost importance. Activities such as seed sowing and the taking of cutting shall be carried out within the critical few weeks when they will yield the desired results. Most other operations, such as spacing out, root pruning and watering, shall also be carried out in a timely manner in accordance with the Nursery Calendar published by the Geo-Environmental Unit of the Department of Roads. The

Contractor shall be responsible to keep works to the strict schedule required and under no circumstances to permit delays.

(f) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Engineer. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(1) Nursery Production of Grass

(a) Grass shall be propagated in nurseries either by seeding in carefully prepared beds or by vegetative propagation.

(b) Where grass seeding is required in the nursery, finely sieved fertile soil mixed with clean sand to a texture of sandy loam shall be placed in beds before the seeds are sown. Seeds shall be covered with a sheet of hessian jute until they have germinated, then it shall be carefully removed. Watering of fresh seedlings shall be done by a fine spray and not by the rose of a watering can.

(c) Grasses to be propagated by vegetative methods shall be of the species instructed. The Contractor shall obtain adequate quantities of the plant material required, butunder no circumstances shall he to cause serious depletion of grass stocks in any steep or erosion-prone area.

(d) Vegetative propagation shall normally be by rhizome cuttings. With this method, the grass shall be treated in exactly the same way as a bamboo being propagated by the traditional Nepalese farmer's technique. A clump shall be carefully dug up and brought to the nursery, being kept cool and damp at all times. Stems shall be cut above the first or second node above the ground: this usually gives a length of 100 to 200 mm. The clump shall be separated carefully, with the minimum of damage to the rhizomes and fine roots. Slips shall be separated out which keep a length of stem and about 50 mm of the rhizome. Each slip shall have some buds on the rhizome, but in some grasses these can be difficult to see. The slips shall be planted with the soil surface at the same level as it was originally, in rows at 200 mm centres; slips shall be at 200 mm centres within the rows. A sheet of hessian jute shall be placed over the tops of the cuttings. When the new shoots are about 50 mm long, it shall be removed.

(e) Every two to three months, all grasses shall be lifted from the beds, split carefully and replanted. It is normal that, once split out, three times the previous bed area is required. This is a standard practice to bulk up the supply of planting stock without having to degrade the natural vegetation cover in the region of the nursery.

(f) Measurement and payment: The basis of measurement shall be the actual area of live grasses covered surfaces in sq.m. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be considered the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(2) Nursery Production of Trees and Shrubs in Polypots

(a) Trees and shrubs shall be seeded either in seed beds or directly in polythene pots ("polypots"). Finely sieved fertile soil mixed with clean sand to a texture of sandy loam shall be placed in well shaded beds for seeding. Watering of fresh seedlings shall be by a fine spray, and not by the rose of a watering can.

(b) All pants shall be grown on in pots of dimensions 100 x 180 mm (4 x 7 inches) or greater when laid flat. The pots shall be of black, 200 gauge polythene. They shall have adequate drainage holes at the bottom and be filled with fertile forest topsoil mixed with clean sand to a texture of sandy loam.

(c) Roots protruding from the bottom of pots shall be pruned with a razor blade on regular basis which shall not exceed weekly and may need to be more frequent. Protruding roots shall never be allowed to become more than 25 mm in length.

(d) When polypot seedlings begin to compete with each other for light, they shall be re- spaced as required. This would typically mean doubling the bed space occupied by the plants.

(e) To be acceptable for planting on site, trees and shrubs shall be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They shall be at least 300 mm in height above soil surface level and of good form. The roots shall be in good condition and there should be no signs of disturbance to the soil in the polythene pot, even after transport to site.

(f) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Engineer. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(3) Nursery Production of Hardwood Plants by Vegetative Methods

(a) Trees and shrubs which can be propagated by vegetative methods may be specified by the Engineer. The Contractor shall produce these by the appropriate method, as required.

(b) All cuttings and stools shall be made as specified in Sub-clause 2803(2) and planted in fertile soil beds of the type specified in Sub-clause 2804 (2).

(c) Cuttings shall be planted 300 mm apart in holes slightly larger than their diameter. They shall be placed at such a depth that only one bud remains above the soil surface (ie about 30 mm of the cutting).

(d) When plants compete with each other for light, they shall be cut back as necessary.

(e) To be acceptable for planting on site, trees and shrubs produced in this way must be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They shall be at least 500 mm in height above soil surface level and of good form.

(f) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Engineer. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(4) Extraction of Plants from the Nursery

(a) The Contractor shall be responsible for extracting plants from nursery beds and preparing them ready for transport. They shall be extracted from the beds only on the morning that they are required for planting on site.

(b) Plants shall be hardened off, starting at least two weeks before they are to be taken out of the nursery. This process shall require a gradual reduction in the amount of watering and shading. The aim is to prepare them for transfer to a much more hostile location.

(c) The night before the plants are to be lifted, they shall be thoroughly watered. This is to make the soil softer and ease the business of extracting the roots.

(d) Plants growing in soil beds shall be carefully lifted from the soil. There shall be no pulling of stems or roots, but they shall be dug out and extracted with no strain on any part of the plant.

(e) Plants from soil beds shall be wrapped in wet hessian jute. Hardwood plants shall have a ball of soil around the roots. Grass clumps can have most of the soil shaken or washed off.

(f) Polypot seedlings shall be lifted and stacked neatly in metal or wooden trays. They shall always be lifted by the pot and never by the stem or leaves.

(g) All plants shall to be kept moist, in a cool, shady place, until they are loaded for transport to site. In the vehicle, they shall not be stacked high. For transport on rough roads, they shall be packed in carefully so that they do not fall over or roll around. The vehicle shall be shaded.

(h) Measurement and Payment: The basis of measurement shall be the actual numbers of plants counted, certified and accepted by the Engineer. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

(5) Compost and Mulch Production

(a) The Contractor shall produce compost and mulch for nursery or site operations. It shall be produced in a timely manner, in the quantities required. Compost is normally required to sustain the long term fertility of nursery beds. Mulch may also be used in the nursery, but normally produced to enhance site planting works, particularly the direct seeding of grass.

(b) Compost and mulch shall be made from annual and perennial weeds of poor rooting characteristics, such as ban mara (Eupatorium adenopherum) and tite pate (Artemesia vulgans). The greenery shall be collected when there is most material available but before it forms seeds. This is most often in Shrawan and Bhadra.

(c) Collected material shall be chopped finely and stored in a mound, compost bay or pit. The maximum size for chopped compost is 50 mm; the maximum size for chopped mulch is 150 mm.

(d) Both compost and mulch shall be kept moist but not waterlogged and in an aerated condition. They shall be completely turned once a month on a regular schedule. Compost can have cow manure mixed in to assist the process of decomposition.

(e) Neither compost nor mulch shall be applied until they are fully rotted. By this time they shall be black and the parts of individual plants shall be indistinguishable. Early application shall not be allowed as this can

lead to a nutrient loss in the soil if microbes extract nitrogen to decompose the added organic material.

(f) Measurement and Payment: The basis of measurement shall be the actual quantity of compost and mulch provided, accepted and certified by the Engineer in cu.m. or kg. Quantities measured as above shall be paid at the unit rates entered in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for executing all the works as specified in these Specifications.

2806. FINAL SLOPW PREPARATION FOR BI0-ENGINEERING

(a) The Contractor shall prepare slopes for planting operations as required by the engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

(b) In the course of all slope preparation works, it shall be essential that no damage is done to existing vegetation unless the Engineer's instruction specifically requires certain plants to be removed.

(c) The timing of bio-engineering operations shall be of the utmost importance. Activities such as planting and seed sowing shall be carried out within the critical few weeks when they will Yield the desired results. All other operations shall be carried out in timely manner to permit this to happen. The contractor shall be responsible to keep works to the strict schedule required and under no circumstances to permit delays.

(d) As slope trimming business can be dangerous and risky to personnel, the Contractor shall be responsible to ensure the safety of his/her and Client's personnel while putting in the dangerous situation. It shall be essential to have the minimum of safety measures as listed below for a working gang of 10 people. The proportion of the safety harness shall be increased according to the requirements and labours employed on site.

The Contractor shall provide all safety measures as listed in Table 28.4 for his/her workers who will be on site and Employer's personnel who will be supervising the work within the Contractor's working premises.

Table 28.4: Materials Required for Safety Measures

S.No.	Description	Quantity
1	Safety rope (mountaineering type or similar make having a min 20 mm diameter and 30 meter in length.	For every workers
2	Safety belt similar to tree climbers or scafolders use.	For every workers
3	Goggles and dust proof masks	For every workers
4	Safety hats	For every workers
5	Knee pad	For every workers

6	First aid kit with necessary medicines and bandages.	1 box per working gang
7	Stretcher	1 no. per working gang

(1) Cut Slope Preparation for Grass Planting

(a) The objective of final cut slope preparation shall be to produce a surface adequately prepared for grass planting. Grass lines shall be used to provide a strong surface cover. Grass lines shall be planted over a well prepared surface. The slope shall not be subject to any undue stress from erosion and mass movement in its initial stages.

(b) All the construction work shall be checked prior to slope trimming. The site shall be clear of people and equipment.

(c) Trimming shall be as follows:

new sites: trimming to straight plan section;
retaining wall to be filled behind;

old sites: minor trimming only required on part of site;
keeping rill or gully pattern in plan section;

(d) The Contractor shall ensure that the slope under instruction is trimmed to a straight angle, according to the Engineer's instructions. Cut slopes to be planted with grass shall normally be 3 vertical: 2 horizontal, unless otherwise shown on the Drawing or instructed by the Engineer. In any event, a straight profile shall be obtained. Concavities shall filled with well compacted material or dry stone dentition as instructed by the Engineer. Convexities shall be removed and it shall be ensured that the general profile does not have a shape giving over-steep segments

(e) All loose material shall be removed from the slope and tipped elsewhere in an approved location.

(f) Measurement and Payment: Work shall be measured in square meters on the basis of actual area of trimmed surface. The payment shall be the full and the final compensation to the contractor for making arrangements for traffic control, trimming, removal of loose materials, all labour, tools equipment, safety harness and incidentals to complete the work as specified herein.

(2) Final Preparation of Fill Slopes for Bio-Engineerings.

(a) The objective of the final preparation of fill slopes shall be to produce a surface adequately prepared for shrub or tree planting or grass sowing, or a combination of these. Vegetation shall be used to provide a strong surface cover. Vegetation shall be planted over a well

prepared surface. The slope shall not be subject to any undue stress from erosion and mass movement in its initial stages.

(b) The Contractor shall ensure that the slope under instruction is trimmed to a straight angle, according to the Drawing or instruction of the Engineer. In any event, a straight profile shall be obtained. All masses of loose debris, especially where it has previously been tipped at the head of the slope, shall be removed. Concavities shall be filled with well compacted material or dry stone dentition as shown on the Drawing or instructed by the Engineer. Convexities shall also be removed and it shall be ensured that the general profile does not have a shape giving over-steep segments.

(c) All loose material shall be removed from the slope and tipped elsewhere in an approved location.

(d) Measurement and Payment: The work shall be measured in square meters on the basis of actual area of trimmed surface as shown on the Drawing or instructed and approved by the Engineer. The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. Such payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, trimming, removal of loose materials, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein.

2807. SITE PLANTING AND SOWING

(a) The Contractor shall plant or sow grasses, shrubs and trees as shown on the Drawing or required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

(b) Due to the nature of bio-engineering works, they may also be undertaken by small local contractors with a range of agricultural skills, if so provided in the Contract. If provided in the Contract, any bio-engineering site activity may also be managed by direct employees of the Division Road Office.

(c) It shall be the Contractor's responsibility to ensure that all planting stock, whether provided from a nursery under a separate contract or through a separate instruction, is of high quality and is vigorous enough to grow on the site to be planted.

(d) All seeds and other planting stock shall be of species indigenous to Nepal unless otherwise specified. All species shall be covered in the current approved lists of species produced from time to time by the Geo-Environmental Unit of the Department of Roads. They shall be appropriate for the precise site conditions in which they are to be planted and the

Contractor shall ensure that they apply to the specific altitude and other environmental characteristics of the site in question.

(e) Activities such as planting and seed sowing shall be carried out within the critical few weeks when they will yield the desired results. All other operations shall be carried out in a timely manner to permit this to happen. The Contractor shall be responsible to keep works to the strict schedule required and under no circumstances to permit delays.

(1) Sowing of Grasses on Site

(a) The Contractor shall be required to carry out the sowing of grass seeds according to the Engineer's specific instructions.

(b) If the site for sowing is to be prepared under a separate contract, then it shall be assumed that the site will already have been prepared for seed sowing. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses.

(c) The Contractor shall be required to supervise all field operations very closely. The sowing of grass seeds is a delicate business and shall be approached in the same way as for agricultural crops. The Contractor shall employ experienced agricultural labourers for this work.

(d) If seeds have to be provided under a separate contract, then they shall be properly stored. However, it shall be the Contractor's responsibility to check that it has been carefully stored and remains fully viable.

(e) Immediately before sowing, the ground surface shall be lightly scarified using a rake to ease early root penetration. Seeds shall then be laid thinly over the surface. Under no circumstances shall they be broadcast, because the lightness of perennial grass seeds and the steepness of the slopes to be treated give a poor cover using such a technique. The Contractor shall be responsible for ensuring that the correct quantities of seeds are used, while giving a good, even cover.

(f) A cover of 25 grammes of grass seed per square metre of surface shall be achieved unless otherwise specified.

(g) After sowing, a mulch of prepared and dried cut herbs shall be laid over the whole seeded area in a thin layer. If the mulch is too thick it will prevent light from getting to the seed and will inhibit germination. Herbs suitable for this and locally available in large quantities are:

- Tite pate (Artemisia vulgans);
- Tapre (Cassia species);
- Ban mara (Eupatorium adenophorum).

However, freshly cut herbs shall not be used because of the danger of resprouting and weeding.

(h) If specified, the mulch should be secured with jute netting of mesh size 300x 500 mm and the netting fixed in place using suitable live pegs or hardwood cuttings (eg Simali, Vitex negundo) at one metre centres.

(i) Measurement and Payment: Work shall be measured in square meters on the basis of actual area of grass seeded and covered surface. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, providing seeds, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein. If the seeds and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply and storage of seeds and mulch no separate payment shall be made for these items.

(2) Direct Seed Sowing of Shrubs and Trees on Site

(a) The Contractor shall be required to carry out the sowing of shrub and tree seeds according to the Engineer's specific instructions.

(b) It is assumed that the site will already have been prepared for seed sowing, if this item has to be executed under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of shrubs and trees.

(c) The Contractor shall be required to supervise all field operations very closely. As the sowing of any seeds is a delicate business and, therefore, shall be approached in the same way as for agricultural crops. The Contractor shall employ experienced agricultural labourers for this work.

(d) Seed shall have been collected and stored well before the time of sowing, if they have to be supplied under a separate contract. However, it shall be the Contractor’s responsibility to check that it has been carefully stored and remains fully viable.

(e) Sowing shall start at the top of the slope and the labourers shall work downwards. Care shall be taken not to disturb areas already seeded.

(f) To sow the seeds, a small hole shall be made in the slope. The tool used to do this shall depend on the size of the seed. For some seeds, a piece of gabion wire will be adequate; for others, a piece of mild steel with a flattened end is required. The hole shall be in the best soil available but if there is little real soil, then a crevice between two stones is acceptable. Two seeds should be placed in each hole and a

covering of soil or whatever fines are available shall be placed over them. This covering shall never exceed 10 mm and shall preferably be about 5 mm; it shall never be less than and this. Seeds shall be placed at 200 to 250 mm centres, as ground conditions dictate.

(g) In some cases the seed can be broadcast starting at the top of the site and working down slope as evenly as possible so that the whole site is lightly covered. This shall be used where the site is still active and only warrants minimum expenditure, or where the site is naturally rough, providing plenty of niches in which the seed can catch. Quantities of seed shall depend on the type of seed involved but are generally half that of the quantities used in the nursery unless otherwise instructed by the Engineer. With utis (Alnus nepalensis) seed it shall be at a rate of 1 gramme of seed per square metre.

(h) Measurement and Payment: Work shall be measured in square meters on the basis of actual area of grass seeded and covered surface. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, providing seeds, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein. If the seeds and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply and storage of seeds and mulch no separate payment shall be made for these items.

(3) Site Planting of Grass Slips and Cuttings

(a) The Contractor shall be required to carry out the planting of grass seedlings or rooted the cuttings, according to the Engineer's specific instructions. The configuration of planting shall be determined according to individual site conditions. It shall be either random, contoured or downslope, as instructed by the Engineer.

(b) It is assumed that the site shall already have been prepared for planting, if this is to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of grasses, and accords with the specifications given in Clause 2806.

(c) Using appropriate tools (such as tape measures and spirit levels), planting lines shall be marked out with string as required. Unless specified differently, the row spacing to be marked out shall be as shown in Table 28.5.

(d) The Contractor shall be required to supervise all field operations very closely. Since the planting of grass slips is a delicate business and therefore shall be approached in the same way as the transplanting of

millet seedlings. The Contractor shall employ this experienced agricultural labourers for this work.

Table 28.5: Row Spacing Details

Planting configuration	Slope steepness	spacing
Random lines	All slopes	100 mm planting drill to drill
Contour lines	Slopes less than 35^o	100 mm planting drill to drill and 1000 mm between the lines
	Slopes 35^o - 45^o	100 mm planting drill to drill and 500 mm between the lines
	Slopes more than 45^o	100 mm planting drill to drill and 300 mm between the lines
Diagonal	Slopes less than 35^o	100 mm planting drill to drill and 500 mm between the lines
	Slopes more than 35^o	100 mm planting drill to drill and 300 mm between the lines
Downslope lines	All slopes	100 mm planting drill to drill and 300 mm between the lines

(e) The plants supplied to the Contractor from nursery (if so provided in the Contract) shall be prepared for planting by the Contractor as given below. The Contractor shall transport them from the nursery wrapped in hessian jute. At all times, plants shall be kept moist and as cool as possible, and should be wrapped in wet hessian between all operations such as extraction from the bed, pruning and planting. Under any circumstances, all plants supplied shall be planted within two days of that they are lifted from the nursery.

(f) Grass slips or cutting shall be carefully separated from the clumps to give the maximum viable planting material. Preparation of slips, cuttings or rhizomes shall be strictly followed as mentioned in Sub-clause 2803 (1).

(g) Planting shall be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a flattened end), a hole shall be made that is just big enough for the roots. The slip or cutting is inserted; care shall be taken that the roots are not tangled or bent back to the surface. Soil shall then be replaced around the roots and firmed with the fingers. The spacing of plants within rows shall be 100 mm unless otherwise specified. Two grass slips shall be planted in each drill.

(h) If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall be required to water for the first two weeks after planting in the event of inadequate rainfall.

(i) If it provided in the Contract that the plants are to be collected from locations other than nurseries then utmost care shall be taken to minimise disruption to neighbouring land, in the event that species are collected from areas surrounding the road. It shall be the Contractor's responsibility to collect the stock required from a wide area and not to give rise to any soil erosion through the excessive removal of plants in one locality.

(j) Measurement and Payment: The measurement shall be the actual area of grass planted and covered surface in square meters for the random planting and any other patterns of planting up to the 300 mm between the lines. The contour line planting in 500-1000 mm in any slopes shall be measured in linear meter. The payment shall be the full and final compensation to the Contractor for making arrangements for traffic control, providing grass slips or rhizome, collection of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the grass slips and mulch are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply slips and mulch, no separate payment shall be made for these items.

(4) Site Planting of Shrubs and Trees raised in Polythene Pots

(a) The planting of trees and shrubs is intended to replace or restore something of the natural vegetation on the slope to be treated. The Contractor shall be required to carry out the planting of seedlings to the Engineer's specific instructions.

(b) It is assumed that the site will already have been prepared for planting if it has to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

(c) The spacing of plants shall be determined according to individual site conditions. However, it shall normally be at 1.5 meters interval unless otherwise specified or instructed by the Engineer.

(d) The Contractor shall be required to supervise all field operations very closely. As the planting of trees and shrubs is a delicate business and should be approached in the same way as the planting of horticultural seedlings. The Contractor shall employ experienced agricultural or forestry labourers for this work.

(e) If the plants are to be supplied to the Contractor from a nursery under a separate contract, they will be ready for planting. They shall be at least 300 mm in height above the soil surface and hardened off in the normal way. The Contractor shall collect the plants from the nursery

and transport them to site with all due care. The plants will normally be supplied in polythene pots, which shall not be removed until the moment of planting. Plants shall be lifted by the pots, never by the stem or leaves. At all times they are to be kept as cool as possible. The Contractor shall be responsible for ensuring that the soil around the roots does not dry out. Under any circumstances, all plants supplied must be planted within three days of removal from the nursery.

If it is provided in the Contract that the Contractor is responsible for the supply of land, plants, he shall maintain the same workmanship and standard as specified herein.

(f) Planting shall be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed.

(g) A planting pit wide and deep enough for the main root to be buried in without bending it and wide enough for all the roots and surrounding soil ball shall be made at the time of planting. Some compost if available shall be mixed with the soil from the slit prior to backfilling around the roots. The polythene pot must be removed from the seedling by cutting it away with a razor blade. The plant should then be carefully placed into the hole, the compost and soil packed in, and all surrounding soil firmed up, taking care not to cause any damage to the plant or its roots. The surface over and around the pit shall then be mulched using any appropriate, locally available material, such as manure, compost, dead leaves or cut herbage. The use of freshly cut ban mara (Eupatorium adenophorum) shall be avoided, since it can resprout from the buds after being cut.

(h) The Engineer may specify bigger seedlings for specific areas, such as those to be used intensively for amenity purposes. These will normally have been growing in a nursery for at least a year and should have well developed roots as well as aerial parts. They will be provided either as bare root stock with a substantial root ball, or in pots of a minimum of 100 x 180 mm laid flat dimensions. When these larger seedlings are planted, the pits shall be of 300 mm diameter and 300 mm depth. In addition, well-rotted compost shall be mixed with the soil backfill in a ratio of at least one part compost to ten parts soil.

(i) Measurement and Payment: The measurement shall be made in number of seedlings planted, counted and accepted by the Engineer at site. The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, providing seedlings, collection and application of mulch, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the seedlings and mulch are supplied through a separate contract, costs for the supply of the same

shall not be included herein. However, if the Contractor is responsible for the supply seedlings and mulch, no separate payment shall be made for these items.

(5) Site Planting of Hardwood Cutting

(a) Certain trees and shrubs can be planted on site by means of hard wood cuttings. Where these are specified, the Contractor shall be required to carry out the planting of cuttings as required in the Engineer's instructions.

(b) It is assumed that the site will already have been prepared for planting, if it is to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

(c) The spacing of hardwood cutting shall be determined according to individual site conditions. However, it will normally be at 500 mm centres unless otherwise specified.

(d) The Contractor shall be required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and shall be approached in the same way as the planting of horticultural cuttings (e.g. those of tea). The Contractor shall employ experienced agricultural or forestry labourers for this work.

(e) The cuttings supplied to the Contractor will normally be from a nursery as arranged by separate instructions, and will be ready for planting. If these cuttings are to be provided by the Contractor himself, he shall make such arrangements so as to make the cuttings ready for planting. The size of the cuttings shall be prepared as specified in Sub-clause 2803 (2) unless otherwise instructed by the Engineer. The Contractor shall collect the cuttings from the nursery (if provided in the Contract) and transport them from the nursery wrapped in hessian jute. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet hessian between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted from the nursery.

(f) Planting shall be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed. Using a small bar (usually made of mild steel and with a pointed end), a hole shall be made that is just big enough for the cutting. The cutting shall be inserted and the soil shall be replaced around it and firmed with the fingers. The cutting shall be inserted to depth such that two-thirds to three-quarters of it is buried.

(g) If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall be required to water for the first two weeks after planting in the event of inadequate rainfall.

(h) If it is provided in the Contract that the cuttings to be used are to be from elsewhere other than nurseries then the Contractor shall obtain them in the manner described in Sub-clause 2803 (2).

(i) The Engineer may specify bigger cuttings for specific areas, using large truncheon cuttings. In this category fall chuletro (Brassaiopsis hainla), dabdabe (Garuga pinnata), kavro (Ficus lacory, phaledo (Erythrina species), ghurbis (Leucosceptrum canum) and Gliricidia sepium. Cuttings of these species should planted at 1000 mm centres burring upto 500 mm. A large crowbar shall be used to make the planting hole, but otherwise the technique shall be as described above for smaller cuttings. Under no circumstances shall these cuttings be hammered into the ground.

(j) Measurement and Payment: The measurement shall be made on the basis of per number of cuttings planted, counted and accepted on site by the Engineer. The quantities measured shall be paid at the unit rates shown in the Bill of Quantities. This payment shall be the full and final compensation to the Contractor for making arrangements for traffic control, providing and delivering seedlings, all labour, tools, equipment, safety harness and incidentals to complete the work as per these Specifications. If the seedlings are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply seedlings, no separate payment shall be made for this item.

(6) Brush Layering, Palisades and Fascines

(a) Under certain conditions, the Contractor shall be required to construct vegetation structures using hardwood cuttings. Where these are specified, the Contractor shall be required to carry out the necessary preparation and planting works as required in the Engineer's instructions.

(b) It is assumed that the site will already have been prepared for planting, if it has to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the successful establishment of delicate young plants.

(c) The cuttings supplied to the Contractor may be from a nursery as arranged under a separate contract, and will be ready for planting. If the cuttings have to be arranged by the Contractor, he shall ensure that they are ready for planting. The cuttings shall be prepared as specified

in Sub-clause 2803 (2) or as instructed by the Engineer. The Contractor shall collect the cuttings from the nursery and transport them from the nursery wrapped in hessian jute. At all times, cuttings shall be kept moist and as cool as possible, and shall be wrapped in wet hessian or in the thick blanket of mulch material (i.e. as tite pati and ban mara) between all operations such as cutting from the parent plant, trimming and planting. Under any circumstances, all plants supplied shall be planted the same day that they are lifted from the nursery.

(d) If the instruction to the Contractor includes the provision of cuttings, then the Engineer shall specify the species and expected sources, and the Contractor must then obtain the cuttings required. This shall be done in the manner described in Sub-clause 2803 (2) except that the size of cuttings will be of a minimum length of 450-600 mm for brush layering, 600 mm for palisades and 1000 mm for fascines, and minimum diameters of 20-30 mm for brush layering and palisades and 40-50 mm for fascines.

(e) Cuttings of the following species, if specified for the truncheon cuttings planting, shall be a minimum of 2500-3000 mm in length: chuletro (Brassaiopsis hainla), dabdabe (Garuga pinnata), kavro (Ficus lacory, phaledo (Erythrina species), ghurbis (Leucosceptrum canum) and Gliricidia sepium.

(f) The Contractor shall be required to supervise all field operations very closely. The planting of tree and shrub cuttings is a delicate business and shall be approached in the same way as the planting of horticultural cuttings (e.g. those of tea). The Contractor shall employ experienced agricultural or forestry labourers for this work.

(g) Planting shall always be started at the top of the slope and under no circumstances shall new plants be walked on or otherwise disturbed.

(h) Brush layering on road embankment slopes shall be planted as given below, unless specified differently.

(i) Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines should be marked out. From 1.5 meters below the road edge, a precise contour line should be marked out on every 1 meter down the slope.

(ii) After the line marking is completed, starting at the bottom of slope, a back sloped terrace (1: 10) of approximately 300 mm in width x 100 mm inner depth and 300-400 mm outer depth should be excavated along the lines. The terrace must not be allowed to open more than 5 metres length at time before planting work is completed.

(iii) Topsoil or agricultural soil of maximum depth of 100 mm from the ROW should be collected and laid on the terrace. The minimum thickness shall be 50 mm unless otherwise instructed by the Engineer.

(iv) Cuttings should then be placed into the terrace at 100 mm centres, the correct way up and angled so that they are at rightangles to the maximum slope angle. All cuttings should be inserted to a depth such that two-thirds of their length is buried.

(v) The terrace should then be partially backfilled with another 50 mm thick layer of topsoil and another line of cuttings placed (pushing into the soil) along the terrace at 100 mm centres, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 50 mm final gap on each brush layer (i.e. 21 cuttings per linear metre).

(vi) When a practical working length is completed, formation of second terrace is then started. As the excavation is undergoing, the partially backfilled brush layering terrace below should be fully backfilled using the material comes out of the second terrace and gently compacted. Any loose or excess material is cleared down the slope making the complete daylight upon the completion of whole slope.

(i) Brush layering on the landslide debris shall be planted as given below, unless specified differently.

(i) Starting at the bottom of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked following a precise contour line at 1 metre interval.

(ii) After the line marking is completed, starting at the bottom of slope, a back sloped terrace (1: 1 0) of approximately 450 mm in width x 100 mm inner depth and 300-400 mm outer depth shall be excavated along the lines. The terrace shall not be allowed to open more than 5 metres length at time before planting work is completed.

(iii) Cuttings shall then be placed into the terrace at 100 mm centres, the correct way up and angled so that they are at rightangles to the maximum slope angle. All cuttings shall be inserted to a depth such that two-thirds of their length is buried.

(iv) The terrace shall then be partially backfilled with 50 mm layer of soil and another line of cuttings placed (pushing into the soil) along the terrace at 100 mm centres, and with the

individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 50 mm final gaps on each brush layer (i.e. 21 cuttings per linear metre).

(v) When a practical working length is completed, formation of second terrace t shall then be started. As the excavation is undergoing, the partially backfilled brush layering terrace below shall be fully backfilled using that material coming out of the second terrace and gently compacted. Any loose or excess material shall be cleared down the slope making the complete daylight upon the completion of whole slope.

(vi) Brushlayering is often done in diagonal or chevron pattern. If it is instructed so, the procedure given above shall be followed accept setting out lines, which shall be changed accordingly.

(j) Palisades shall be constructed as given below, unless specified differently.

(i) Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 1 metre below the top of the slope, a precise contour line shall be marked out every 1 metre down the slope.

(ii) Starting at one end and using a small bar (usually made of mild steel and with a pointed end), a hole shall be made that is just big enough for the first cutting. The cutting shall be inserted and the soil shall be replaced around it and firmed with the fingers. The cutting shall be the correct way up and angled so that it is vertical. The cutting shall be inserted to a depth such that two-thirds of it is buried.

(iii) This process shall be repeated along the entire line, with a series of cuttings placed at 50 mm centres,

(iv) If a double line is specified, then a second line of cuttings shall be placed in the same way, 100 mm behind the first and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line.

(v) The soil around the single or double line shall then be completely backfilled into any remaining gaps and gently compacted. Any loose or excess material shall be cleared down the slope before the next line is planted.

(k) Fascines shall be bundles of hardwood cuttings laid horizontally in trenches, and parallel to the line of the trench. The bundles shall be thereby completely buried. Fascines shall be constructed as given below, unless specified differently.

(i) Starting at the top of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 1 metre below the top of the slope, a precise contour line shall be marked out every 1 metre down the slope.

(ii) Starting at the bottom as the marking is completed, trenches approximately 200 mm x 200 mm in depth shall be excavated along the lines.

(iii) 600 mm long cuttings of same material that is going to make fascine shall be planted on the lower side of trench in vertical position as a peg at 1000 mm interval.

(iv) Cuttings shall then be laid along each trench, so that they lie horizontally along the trench. There shall be a minimum of six cuttings together. They shall be overlapped so that no two ends coincide. All the small branches growing from the main branch shall be protruding on slope. Under no circumstances, the branches and buds shall be damaged. The cuttings shall then be tied using jute or coir (coconut fibre) string at 500 mm intervals to form a bundle. As the fascine is created, it thereby forms a continuous bundle right across the slope.

(v) The trench shall then be backfilled and gently compacted. The top of the fascine shall be 50 to 100 mm below the surface. Any loose or excess material shall be cleared down the slope before the next line is planted.

(vi) The Engineer may specify that orientations other than along the contour of the slope are used. In this event, the Contractor shall alter the laying out of lines accordingly and meet the precise angle required.

(vii) If the soil is dry and there is no rain within 16 to 24 hours of planting, the site shall be watered carefully with a fine spray. The Contractor shall be required to water for the first two weeks after planting in the event of inadequate rainfall.

(l) Measurement and Payment: Brush layering, Palisades and Fascines shall be measured separately as per the accepted final product in linear metre. The payment shall be the full and final compensation to the Contractor for making arrangements for traffic control, collecting and transporting of cuttings to the site, all labour, tools, equipment, safety harnesses and incidentals to complete the work as per these Specifications. If the cuttings are supplied through a separate contract, costs for the supply of the same shall not be included herein. However, if the Contractor is responsible for the supply cuttings, no separate payment shall be made for this item.

(7) Use of Fertiliser

(a) Under certain circumstances, the use of chemical fertilisers may be specified in place of farmyard manure or mulching.

(b) Levels of fertiliser application shall vary according to soil type and nutritional content. However, if nutritional data are not available, the following figures shall be used as a rough guide:

Nitrogen (N) : 10 g/m2;
Phosphorus (P) . 5 g/m2;
Potassium (K) . 4 g/m2.

Table 28.6 below lists the chemical composition and percentage of the major plant nutrient elements in the chemical fertilisers commonly available in Nepal.

Table 28.6 : Chemical Composition of Major Plant Nutrient Elements

Chemical name	Chemical formula	Percentage		
		(N)	(P)	(K)
Sulphate of ammonia	$(NH_4)_2SO_4$	21	0	0
Urea	$CO(NH_4)_2$	46	0	0
Triple superphosphate	$CaH(PO_4)$	0	21	0
Muriate of potash	KCL	0	0	49
Complexol	Unknown	20	20	0
Diammonium phosphate	$(NH_4)_2HPO_4$	18	20	0

2808. JUTE NETTING WORKS

(a) The Contractor shall provide and install jute netting as shown on the Drawing or as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

(b) The Engineer may instruct that jute jetting applications be used in conjunction with other or the techniques, particularly the sowing or planting of grasses. In this event, the netting shall be applied before the plants are introduced. When planting, the labourers shall take care only to hold or stand on the pegs and not to disturb the netting except when carefully placing grass seed underneath on the soil surface.

(1) Supply of Jute Netting

(a) The Contractor shall manufacture or obtain a supply of jute netting to the Engineer's specification.

(b) The detailed specifications for standard jute netting shall be as follows. "Standard" jute netting is used for placing on bare slopes and is normally planted with grasses. (Note: warp ends are the length-ways threads and weft strands are the cross-ways threads)

(i)	Material:	High quality, 100% natural jute fibre from the latest harvest, properly treated and dried.
(ii)	Yarn:	Handspun 5 to 8 mm.
(iii)	Strip size:	minimum 1.0 x 10.0 metres; maximum 1.1 x 11.5 metres.
(iv)	Warp ends:	27 ends per 1000 mm.
(v)	Weft strands:	20 to 24 strands per 1000 mm.
(vi)	Mesh size:	40 mm square mesh holes.
(vii)	Weight:	1.1 to 1.2 kg per square metre.

(c) The detailed specifications for wide mesh jute netting shall be as follows. "Wide mesh" jute netting is used for holding much on to slopes which have been sown with grass seed, (Note: warp ends are the length-ways threads and weft strands are the cross-ways threads)

(i)	Material:	High quality, 100% natural jute fibre from the latest harvest, properly treated and dried.
(ii)	Yarn:	Handspun 3 to 5 mm.
(iii)	Strip size:	minimum 1.0 x 5.0 metres; maximum 1.1 x 11.5 metres.
(iv)	Warp ends:	7 ends per 1000 mm.
(v)	Weft strands:	3 strands per 1000 mm.
(vi)	Mesh size:	150 x 450 mm rectangular mesh.
(vii)	Weight:	0.2 kg per square metre.

(d) Measurement and Payment: No separate measurement and payment shall be made for the supply of jute netting. All costs incurred for the supply of jute netting shall be included in the item rate for the placement of jute netting.

(2) Placement of Small Mesh Size Jute Netting/Standard Jute Netting

(a) The Engineer shall normally instruct the placement of standard jute netting on slopes in excess of 45°. It is therefore very essential to place the netting in an effective manner which fulfils the Engineer's purpose.

(b) It is assumed that the site will already have been prepared for the application of jute netting, if it is to be prepared under a separate contract. Nevertheless, it shall be the responsibility of the Contractor to ensure that the condition of the site is good enough for the optimum effect to be attained. In any event, a smooth profile must be obtained. All loose debris shall be removed. Concavities shall be filled with well compacted material or dry stone dentition as shown on the Drawing or as instructed by the Engineer. Convexities shall also be removed and it is essential that the general profile does not have a shape giving over-steep segments.

(c) Starting at one end of top of the site to be treated, a roll of netting shall be pegged 300 mm above the slope to be covered.

(d) The netting shall be rolled slowly down the slope. Hardwood cuttings, ideally of simali (Vitex negundo) or pegs (usually made from split bamboo culms) shall be hammered through the netting at 1000 mm centres at 100 mm inside of each edges. They shall protrude about 80 mm on the slope. Labourers shall stand on these cuttings or pegs and not hang on to the netting. As the full length of the jute netting is unrolled down the slope, a second round of the pegs shall be added in between. This will make total allowable spacing of not more than 500 mm interval. Another strip shall then be started to unroll from the top. This shall overlap by 100 mm and under no circumstances the pegging is done through the both layer of jute net instead it shall be pegged separately. Each strip of jute netting shall be pegged down on the slope individually.

(e) The tension of the netting shall now be reduced so that it hugs the slope surface precisely. This is done by pulling up about 200 mm at the bottom of the netting and hooking it on to the pegs a little higher up. This process shall be repeated up and across the slope until the netting rests snugly against the surface and is nowhere tight or pulled away from the surface in minor concavities. Additional pegs shall be used to hold netting closely against the face of concave slope segments if necessary.

(f) This process shall be repeated until the entire slope surface is covered. There shall be no lacing of any jute netting whatsoever.

(g) Finally, the bottom of the netting shall be trimmed to give a tidy finish.

(h) Measurement and Payment: As the actual quantity of jute net and area covered on slope differ from each other due to the overlapping, payment shall be made on the basis of final area covered on slope and measured in square metre (not the quantity of jute net). The payment shall be the full and the final compensation to the Contractor for making arrangements for safety to traffics, purchasing of jute, arrangement for looms and shades, fabrication of jute netting and transportation to the site, all labour, tools, equipment, safety harnesses and incidentals to complete the work as per these Specifications.

(3) Placement of Wide Mesh Size Jute Netting

(a) In the case of wide mesh jute netting, it shall only be specified for use on slopes which have already been treated with grass and mulch. These shall usually be less than 45°. However, the process of placing the netting shall be similar to that for standard netting.

(b) Unlike the standard mesh jute net, wide mesh jute net is available on shorter length of 5.5 metres and smaller roll in nature. It shall be opened by two people by two end laid flat (same as bed sheet is laid) on seeded and mulched slope.

(c) The netting shall be pegged with hardwood cuttings, ideally of simali (Vitex negundo) or pegs (usually made from split bmboo culms) at every 500 mm intervals. The Contractor shall ensure that his/her labourers do not damages the area of seeding and mulching while placing the jute net.

(d) This process shall be repeated until the entire slope surface is covered. The strips shall then laced together with lengths of the same jute yarn, to form a continuous net. The lacing shall form joins every 500 mm or less.

(e) The tension of the netting shall now be reduced so that it hugs the slope precisely and hold the mulch firmly against the surface throughout the area covered. Additional pegs shall be used to hold netting closely against the face of concave slope segments.

(f) Finally, the bottom of the netting shall be trimmed to give a tidy finish.

(g) Measurement and Payment: The payment shall be made on the basis of final area covered on slope and measured in square metre (not the quantity of jute net). The payment shall be the full and the final compensation to the Contractor for making arrangements for safety to traffics, purchasing and transporting of jute net to the site, all labour, tools, equipment, safety harnesses and incidentals to complete the work as per these Specifications.

2809. GABION WIRE BOLSTERS, SUB-SOIL DRAINS AND WIRE NETTING

The contractor shall provide and install wire bolsters as shown on the Drawing or instructed by the Engineer. This shall be done according to the specifications described hereunder, as when required.

The Contractor shall supply all necessary expertise, resources and facilities to ensure that these requirements are met.

(1) Fabrication of Bolster Panels

(a) Bolster panels shall be either 5 x 1 metres or 5 x 2 metres in size, according to the type of bolster to be used. If the bolster panels are used for the wire netting, the size of the panel shall be 5.0 m X 5.0 m. They shall be woven with hexagonal mesh in the same way as normal gabion panels. For the panel frame, 10 swg galvanised wire shall be used; for the mesh, 12 swg shall be adequate. Gabion wire shall comply with the requirements of Clause 240.

(b) Weaving shall start from one of the long sides. A total of 83 coils of wire shall be spaced evenly along the 5 metre length. This gives a mesh width of about 60 mm. Each weave shall have three twists, as for normal hexagonal mesh. This shall give a length of about 80 mm to each mesh link. In any event, the mesh length shall not exceed 90 mm. The mesh shall be turned on to the larger frame wire at least one and a half turns and made fully secure.

(2) Placement of Contour Bolsters

(a) A contour bolster treatment shall give a series of stone-filled wire tubes of 300 mm diameter, laid in trenches cut across the slope. The tops of all the tubes shall be flush with the surface of the slope in which they are placed. The purpose shall be to check scour of the slope surface by preventing the development of rills and gullies.

(b) The site to be treated shall be given final preparation immediately before bolster installation. All small protrusions and depressions shall be obliterated by cutting, or by infilling and compaction.

(c) Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 2 metres above the base of the slope, a precise contour line shall be marked out every 2 metres up the slope.

(d) Starting at the bottom, trenches with circular base shall be dug along the lines, adequate to take the final 300 mm diameter tubes.

(e) Bolster panels shall then be laid along the trenches and shaped to fit neatly into the base of the trenches, as well as into any curves formed as a result of the slope contours; each panel shall be securely joined to the next panel, to form a continuous bolster tube.

(f) The panels shall be packed with stones, closed over and the edges wired together. All stones must be bigger than the mesh size. The same care shall be taken as when filling a conventional gabion basket, and stones must be carefully placed to give good structural integrity.

(g) The ends of the bolsters shall be closed over and wired together. The trenches around all the bolsters shall then be filled and compacted with material left from the excavations.

(h) Once all of the lines are in place, all surplus debris shall be cleaned off the slope. Mild steel bars of at least 16 mm diameter shall then be driven into the slope through lower sides of the contour bolsters. These shall be at least every 2 metres along the lines. Bars shall be 1-2 metres in length on slopes composed of soft materials, but at the Engineer's discretion, on slopes comprising hard rocky materials, bars of 1 metre length shall also be adequate. All bars shall be driven home until the tops protrude no more than 25 mm above the slope surface.

(i) Measurement and Payment: Bolster shall be measured as per the accepted final product in linear metre. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, fabrication of bolster panel including cost of wire, collection and transportation of boulder/stone to the site, packing of stones/boulders, wiring, supply and driving of steel bars, excavation and filling, all labour, tools, equipment, safety harnesses and incidentals to complete the work as specified in these Specifications.

(3) Placement of Herringbone Bolsters

(a) A herringbone bolster network is in essence a system of wire tubes of between 300 mm to 600 mm in diameter depending on the amount of water flowing through the site, laid in trenches cut into the slope. The main bolster shall run straight down the slope (the spine) with other running into it at an angle of 45° to the fall of the slope (the herringbones or branches) depending on slope angle and terrain morphology. The purpose shall be to check scour of the slope surface by preventing the development of rills and gullies, and to drain the surface material in a similar way to a French drain. The diagonal components shall be at 2 to 5 metre centres if measured straight down the slope.

(b) The site to be treated shall be given final preparation immediately before bolster installation. All small protrusions and depressions shall be obliterated by cutting, or by infilling and compaction.

(c) Starting at the base of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out: every 7.0 metres across the slope, a line shall run straight up to the top of the slope (these form the main bolster spines). From the base of the line, and every 3 metres above this, other lines of 5 metres length shall be marked at 45° to the main line (these will form the herringbones).

(d) Starting at the bottom, trenches with circular base shall be dug along the lines, adequate to take the final 300 mm diameter tubes, or 600 mm diameter tubes if large (5 x 2 metre) panels are specified.

(e) Bolster panels shall then be laid along the trenches and shaped to fit neatly into the base of the trenches, as well as into any curves formed as a result of the slope contours; the panels of the herringbones shall be securely joined to the panels of the main bolster.

(f) The panels shall be gradually closed together and secured, working up from the bottom of the slope, while stones are passed in from above to fill them. The stones shall be randomly packed so as to allow free drainage, and all stones shall be bigger than 100 mm. The same care shall be taken when filling a conventional gabion basket, and stones shall be carefully placed to give good structural integrity.

(g) The upper ends of the herringbones shall be closed over and wired together; they should touch the ends of the next herringbones but shall not be secured (hooked) to each other. The trenches around all the bolsters shall then be filled and compacted with material left from the excavations.

(h) Once all of the lines are in place, all surplus debris shall be cleaned off the slope. Mild steel bars of at least 16 mm diameter shall then be driven into the slope through the sides of the main spine bolsters and the lower sides of the herringbone bolsters. These shall be at least every 2 metres along the lines. Bars shall be 1-2 metres in length on slopes composed of soft materials, but at the Engineer's discretion, on slopes comprising hard rocky materials, bars of 1 metre length may be adequate. All bars shall be driven home until the tops protrude no more than 25 mm above the slope surface.

(i) Measurement and Payment: Bolster that are accepted by the Engineer shall be measured in linear metre. The payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, fabrication of bolster panel including cost of wires, collection and transportation of boulder/stone to the site, excavations and fillings, boulder/stone packing, all wiring, supply and driving of steel bars, all labour, tools, equipment, safety harnesses and incidentals to complete the work as specified in these Specifications.

(4) Wire Netting

(a) Wire netting shall be a complete cover on the steep rocky slope where heavily shattered rock face is eroding away by surface water. The site shall be prepared as outlined in Clause 2806. A wire mesh panel, normally larger than bolster, of 5 m x 5m shall be placed over the slope and later plant will be grown to replace the wire netting.

(b) The site to be treated shall be given final preparation immediately before wire netting. All loose bulging shall be trimmed off.

(c) Starting at the top of the slope to be treated, wire netting shall be placed securing well on to the slope. The wire net shall then be stapled down with an "U" shaped hook.

(d) The hook shall be made of 16 mm diameter M/S rod and a minimum of 1000 mm in length. The hook shall be driven hammering down with the mason's hammer at 500 mm interval. This will be effective if driven into the cracked joint. A shorter length may also be used if the rocky face does not permit the bar, but the Engineer's approved and instruction shall be obtained prior to taking a decision.

(e) The wire netting shall be well secured. If there are any minor concavity and convexity, the wire shall be secured by hammering down by mason's hammer. Additional staples could be used as necessary. If some of the staples become weak and loose, they shall be jammed with 1:4 cement sand mortar in slurry form.

(f) Measurement and Payment: Wire netting shall be measured in square metre. The her; they payment shall be the full and the final compensation to the Contractor for making arrangements for traffic control, purchasing of wire net, fabrication and transportation of wire netting to the site, supply and driving of hooks, all labour, tools, equipment, materials, safety harnesses and incidentals to complete the work as specified in these Specifications.

(5) Construction of Sub-soil Drains (Sub-surface Drains)

Sub-soil drains shall be installed and paid in accordance with the requirements specified in Clause 2404.

2810. SITE PROTECTION

(a) The Contractor shall protect a planted site for the period specified in the Contract. Protection shall be shall include the prevention of damage to all manner of site works and plants by people and domestic or wild animals. It shall also include an active role in tending the plants and improving their growth, as specified below.

(b) The period of maintenance/site protection shall be twelve months unless otherwise specified in the Contract.

(1) Provision and Role of Site Warden

(a) The Contractor shall be required to provide an adequate number of site wardens to look after the site to fulfil the specified requirements. The function of Warden shall be broader than that of watchman, chowkidar, or heralu. It shall also involve a number of routine maintenance operations.

(b) Warden shall be mature and reliable characters who need little supervision for the adequate fulfillment of their duties. They shall be active and physically fit. Old people who are losing their strength shall not be employed. They shall be experienced agricultural workers familiar with caring for plants. They shall. remain on site through all hours of daylight and through all adverse weather conditions. They shall eat their meals on site and at no time leave the site untended for any reason whatsoever.

(c) The role of the Warden shall be primarily to tend the plants. He/she shall take the initiative in weeding, mulching, replanting failed plants, pruning and protecting plants against all pests. This shall be an active role requiring individuals with considerable energy and initiative. The Warden shall work constantly to maintain and improve the site and its bio-engineering plants.

(d) The Warden shall also be required to protect plants on the site from damage by local people, domestic and wild animals. In doing this he/she shall use a friendly approach to the people as far as possible. The Contractor shall educate the Warden fully in the reasons for his/her job, so that he/she can communicate with others. He/she also shall have to fulfill an inevitable function as the ambassador between the Department of Roads and local road neighbours.

(e) Measurement and Payment: Site Warden employed under the Contract shall not be paid for separately. All costs associated with the employment of warden as well as execution of works specified shall be considered to be included in the item rate of "Site Aftercare and Maintenance".

(2) Fabrication of Bamboo Tree Guards

(a) The Contractor shall provide bamboo tree guards as shown on the Drawing or specified in the Contract. This shall be done according to the specification described hereunder, as and when required. The Contractor shall supply all necessary supervision, resources and facilities to ensure that these requirements are met.

(b) The bamboo strips used to make bamboo tree guards shall be made from mal bans (Bambusa nutans subsp cupulata) whilst the uprights are to be made from tharu or dhanu bans (Bambusa nutans subsp nutans or Bambusa balcooa). Bamboo tree guards shall be a minimum of 450 mm in diameter by 1300 mm in height so that they are able to provide sufficient protection from grazing and from the elements for the first 18 months after planting the seedling.

(c) The guard shall be made by cutting 5 bamboo posts which are a minimum of 50 mm wide by 10 mm thick and at least 1600 mm long. The posts shall be cut so that they have a strong spear-like point at the bottom that can be driven into the ground when placing out on site. The bamboo poles used to make the uprights shall be a minimum of 3 years old.

(d) Bamboo strips, a minimum of 5 mm thick and 50 mm wide shall be cut from poles that are at least 2 years old. The bamboo used shall be split so that the outer wall remains intact. Only lengths with the outer wall intact shall be used. The split bamboo shall be the length of the whole bamboo pole that it is cut from, or as long as possible. The split bamboo shall be woven in and out of the bamboo uprights and pulled tight, so that it is firm and strong. The end of each of the strips shall be woven back into the basket and tied with binding wire to keep it in place. End pieces shall not be left sticking out and unbound, because they quickly get broken and the basket starts to unravel from this point. The split bamboo shall be woven round the poles so that when they are tightly pressed down there are no gaps in the guard.

(e) Measurement and payment: No separate payment shall be for the fabrication of the bamboo tree guards. All associated costs shall be considered to be included in the item rate for "Site Aftercare and Maintenance".

(3) Placement of Bamboo Tree Guards

(a) Tree guards shall be installed on site at the time of planting, no later than the second week of July, and shall be placed carefully around the planted seedlings.

(b) The tree guards shall be placed over the seedling immediately after planting. The upright posts shall be firmly driven at least 300 mm into the ground so that the guard is able to resist bashing and rubbing from cows, buffalo, goats and people. The woven slats shall be pushed down firmly from the bottom upwards so that they touch one another and are free from large gaps.

(c) Tree guards alone are not adequate protection for small plants. The Contractor shall provide a site Warden in addition, for the time specified, to maintain the tree guards and ensure that local people

respect them, and generally fulfil all the requirements of Sub-clause 2810 (1).

(d) Measurement and Payment: No separate payment shall be made for the placement of the bamboo tree guards. All the associated costs shall be deemed to be included in the relevant item rate for "Site Aftercare and Maintenance".

(4) Fencing

Fencing shall be executed as described in Section 400 but payment shall be included in the item rate of "Site Aftercare and Maintenance".

2811. SITE AFTERCARE AND MAINTENANCE

(1) The Contractor shall maintain planted bio-engineering sites as required by the Engineer. This shall be done according to the specifications described hereunder, as and when required. The Contractor shall supply all necessary expertise and resources to ensure that these requirements are met.

(2) The Contractor shall carry out weeding as required throughout the site. All annual weeds and other unwanted plants shall be cut just above the ground and the aerial parts will be used to make compost or mulch. Weeds shall not be pulled out by the roots since this disturbs the ground surface.

(3) Weeding shall be carried out throughout the growing season. It shall be undertaken with particular diligence at the end of the monsoon, so that there is the minimum amount of competition during the subsequent dry season.

(4) The Contractor shall carry out mulching as required throughout the site. All plants required under the bio-engineering specifications will be mulched using material prepared as specified in Sub-clause 2805 (5), or the aerial parts of weeds cut on the site or brought from elsewhere for the purpose. The desired plants shall be kept mulched at all times but especial care shall be taken in the spring, when the soil moisture deficit is at its greatest.

(5) The Contractor shall replace failed, damaged, diseased and very weak plants, using fresh, healthy plants of the same species, at the correct time of year for planting. This replanting operation shall normally be carried out during the monsoon in the year following the first planting works. Vegetation structures shall be enriched by the planting of additional cuttings or seedlings, as instructed by the Engineer. Failed seeding areas shall be reseeded at the appropriate time of year.

(6) In replanting and enrichment works, the Engineer may specify the use of different species. This shall be done where failures or poor performance of plants may be attributed to poor stock or an incorrect initial choice of species.

(7) All bio-engineering sites shall be maintained so that there are at least the following two storeys of vegetation. In certain locations, however, there may be a number of additional vegetation storeys.

(a) A dense ground cover of healthy grass plants, in the configuration specified at the time of planting.

(b) An open canopy of shrubs or trees with a deeper rooting network.

(8) In general it shall be necessary to keep the upper canopy thinned in order to maintain the lower ground cover. Most grasses require high light intensities and become degraded if subjected to excessive shade from the overstorey. It shall therefore be the Contractor's responsibility to thin the canopy as necessary to permit adequate levels of light to penetrate for the optimum growth of the grass understorey.

(9) All thinning and pruning operations shall be undertaken in accordance with the guidelines issued by the Geo-Environmental Unit. Since these are skilled silvicultural operation, the Contractor shall take appropriate professional advice and employ suitably skilled personnel.

(10) All products from thinning and pruning operations shall be disposed off in accordance with the regulation of His Majesty's Government. The Contractor shall follow the instructions of the Engineer in this regard.

(11) Other maintenance operations shall to be undertaken by the Contractor according to the instructions of the Engineer.

(12) Measurement and Payment: The works shall be measured in a lump sum basis. The item rate shown in the Bill of Quantities shall be the full and the final compensation to the Contractor for carrying out all works specified herein including provision of site protection specified in Clause 2810.

Should at any time the Engineer give any instruction for the proper Site Protection/Aftercare and Maintenance and the Contractor does not respond within 24 hours, the Engineer shall be empowered to instruct others to carry out the works. Any costs involved by such actions shall be borne by the Contractor.

SECTION 2900 – MAINTENANCE WORKS

SECTION 2900 –MAINTENANCE WORKS

2901. SCOPE

The works mentioned in this Section shall apply to maintenance of road and shall be carried out manually or by machinery in such a way that the quality of end product meets the specified requirements. Whenever the Specification is not clear, good engineering practice shall be applied to the satisfaction of the Engineer.

This Section does not apply to the works as specified in Clause 107 (Maintenance of Road during Construction and Defects Liability Period).

2902. RESTORATION OF RAIN CUTS

The work shall consist of restoration of rain cuts in embankment slopes. The material to be used in the restoration shall be the suitable material conforming to Clause 902.

The affected area shall be cleared of all loose materials and benched to a width of about 300 mm. The height of the bench shall vary according to the slope of the embankment. Suitable material shall be deposited in layers not exceeding 150 mm and shall be watered/dried as required and compacted using suitable tools or hand compactor. The final slope and top surface after completion of the filling shall match with the adjacent slope and surface of the embankment

Measurement

The work shall be measured in cubic meter.

Payment

Quantity measured as provided above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

2903. MAINTENANCE OF EARTHEN SHOULDERS

The work shall include making up of irregularities on the shoulders to the required level and crossfall by adding suitable materials or stripping excess materials and compacting it.

Wherever material is required to be added, the earthen shoulder shall be stripped and loosened upto 100mm depth measured from the existing ground level. The deficiency of thickness shall be made up with suitable material as defined in Clause 902 in layers of loose thickness not exceeding 150 mm. Water shall be added, if required and thoroughly compacted with appropriate equipment to obtain at least 95 % of the MOD in accordance with IS 2720 Part 8.

Wherever the material from the shoulder is required to be excavated, this shall be done by manual means using hand tools or appropriate equipment as directed by the Engineer and shall be compacted, to the 95% of the MDD.

The final surface formed either by addition or excavation of materials shall be uniform, with the cross slope towards the edge of the road width. The top surface along the inner edge of the shoulder shall be flushed with that of the adjacent carriageway.

Measurement

Maintenance of earthen shoulder shall be measured in square meter.

Payment

Maintenance of earthen shoulder shall be paid as per contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

2904. MAINTENANCE OF GRAVEL SHOULDERS AND GRAVEL CARRIAGEWAY

The works shall involve repairing of pot holes and making up of irregularities/loss of materials by adding fresh gravel and/or stripping excess gravel from the surface.

Gravel shall comply with the requirements of Clause 1204 for shoulders and Clause 1205 for gravel wearing course.

Pothole Repair

Each pothole shall be inspected and all loose material shall be removed. The area shall be cut down to the subgrade level in a rectangular shape. The edges shall be cut vertically. The subgrade shall be cleared of all loose materials and hand compacted. Fresh gravel shall be placed in the pit in layers not exceeding 150 mm and the gravel shall be brought to optimum moisture content and well compacted with small rollers or other equipment as directed by the Engineer. The resulting surface shall match with adjacent surface.

Shoulder/Carriageway Repair

The work shall involve:

(a) Making up the irregularities/loss of material by adding suitable gravel and compacting the same; and/or

(b) Stripping extra gravel from the surface to achieve the required grade and level.

Wherever extra gravel is required to be added, the existing surface shall be loosened upto 100mm depth to receive fresh gravel. The deficiency of thickness shall be corrected by adding suitable gravel in layer of 100 mm. The gravel shall be brought to optimum moisture content and thoroughly compacted using roller/compactor to achieve the density as specified in Clause 1205.

Wherever the existing gravel is required to be excavated, this shall be done manually or using equipment like grader. The resulting surface shall then be watered, if required, and thoroughly compacted to achieve the density as specified in Clause 1205.

The finished surface shall have the specified line, level and cross slope. Straight edges shall be used to check the profiles.

Measurement

The maintenance of gravel shoulder and gravel carriageway shall be measured in square meters.

Payment

The maintenance of gravel shoulder and gravel carriageway shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112.

2905. BITUMINOUS PATCH WORKS

This Clause covers the repair of the potholes and the damaged bituminous surface.

(1) Excavation

The area to be repaired shall be marked out in square or rectangular shape, 30mm beyond the extent of the damaged area and shall be excavated with all sides vertical upto required depth.

If the existing road base is damaged, it shall be also excavated to a depth required and removed as directed by the Engineer.

(2) Bituminous Patching

(a) Shallow Patching

Shallow patching shall consist of repairs to the carriageway surface to a depth not exceeding 40mm.

The surface of the excavated area shall be swept clean of dust and other loose materials and shall be primed with MC 30 cutback bitumen. The sides shall also be tacked/primed with cut back bitumen using

brush. The excavated area shall, then, be filled with hot or cold premix material. The premix shall have a net bitumen content of 5% to 6% by weight as directed by the Engineer or as per design mix. The premix shall then be compacted using equipment approved by the Engineer.

After compaction, the surface of the patched area shall be true to the lines and levels of the surrounding existing surface.

(b) Deep Patching

Deep patching shall consist of repairs to the carriageway surface to a depth exceeding 40mm.

The surfacing and underlying courses shall be cut out in square or rectangular shape with vertical sides and to the extent and depth specified by the Engineer. The excavated hole shall be swept clean of dust and all other loose material.

The excavated area in base and subbase shall be filled with approved materials complying with the requirements of base or subbase, as applicable, conforming to Section 1200 and shall be compacted in layers not exceeding 100 mm thickness or as directed by the Engineer.

The surface of the compacted base shall be primed with MC 30 cutback bitumen and filled with hot or cold premix material and compacted as described in shallow patching.

After compaction, the surface of the patched area shall be true to the lines and levels of the surrounding existing surface.

(c) Carriageway Edge Repair

Where loss of bituminous surfacing exist at the edge of the carriageway without damaging the base, edge repair shall be performed as described for shallow patching.

Where damage of the edge extends into the base/subbase, the edge repair shall generally be carried out as specified for deep patching. Excavation shall be to a minimum width of 750 mm covering not less than 200 mm of the carriageway and not loose less than 500 mm of the shoulder. The depth of excavation shall be as directed by the Engineer.

The excavated area shall be filled with base and/or subbase material to a level 40 mm of below the existing level of the road and compacted as mentioned in deep patching. The surface of compacted base and sides of the excavated area shall be primed/tacked with MC 30 cut back to a line 100 mm beyond that of the deep excavation and excavated area

shall be filled with hot or cold premix material and compacted as specified for the shallow patching.

The final surface shall match with the adjacent surface in line and levels.

(3) Tolerances

On completion, the patch shall have the tolerances of -Omm/+6mm, under a straight edge laid across it.

(4) Measurement

The shallow/deep patching and carriageway edge repair shall be measured separately in square meters.

Earth excavation and supply of materials to be used deemed included in the measurement.

(5) Payment

The shallow/deep patching and carriageway edge repair shall be paid at their respective contract unit rates which shall be the full and the final compensation to the Contractor as per Clause 112.

2906. MAINTENANCE WITH SLURRY SEAL

This Clause covers the materials, methods of construction and requirements for the maintenance works with slurry seal.

Slurry seal shall generally be required in the pretreatment of the pavement surface distress such as cracks, ravelling etc.

(1) Materials

(a) Stockpilling of Aggregates

Sites for the stockpilling of aggregates shall be prepared in such a manner that no grass, mud, soil, dust or other deleterious material will be included when the aggregates are loaded for use.

(b) Bituminous Binders

The binder shall be K3-60 slow setting bitumen emulsion or as agreed by the Engineer.

(2) Types of Slurry Seal

According to nature and severity of the distress, three types of slurry seal will be applicable.

- Fine Slurry Seal (i)
- General Slurry Seal (ii)
- Coarse Slurry Seal (iii)

General slurry seal shall be applicable in porous and cracked road surfaces, whereas fine slurry seal shall be used in case of narrowly cracked road surface. For widely cracked and ravelled surface, coarse slurry seal with max. aggregate size of 10mm shall be used as per Clause 1306.

(i) Fine Slurry Seal

A mix, as detailed below will cover approximately 205 sq.m of road.

Aggregate	1 cu.m. (bulk)
Emulsion	250 litres
Cement	17 kg
Water	as required

The grading of the aggregate shall be as per Clause 1306.

(ii) General Slurry Seal Mix

A mix, as detailed below, will cover approximately 180 sq.m. of road.

Aggregate	1 cu.m. (bulk)
Emulsion	250 litres
Cement	17 kg
Water	as required

The grading of the aggregate shall be as per Clause 1306.

(iii) Coarse Slurry Seal Mix

A mix, as detailed below will cover approximately 150 sq.m. of road.

Aggregate	1 cu.m. (bulk)
Emulsion	250 litres
Cement	17 kg
Water	as required

The grading of the aggregate shall be as per Clause 1306.

Maximum batch sizes for each slurry seal mixes will be in the order of 20 kg.

Daily records of consumption of materials and of areas covered shall be kept and agreed with the Engineer.

(3) Equipment and Mixing

(a) Sufficient equipment for handling and hauling aggregate and binder shall be used in order to ensure prompt and continuous covering of bituminous slurry seals as specified. All the necessary ancillary equipment and hand tools to carry out the work efficiently shall be available.

(b) In general a rotary type concrete mixer will be suitable to prepare slurry seal mix at the site itself unless otherwise alternative arrangement made by the Contractor to the satisfaction of the Engineer. The concrete mixer may be mounted at the back of a flat bottom truck which is also loaded with stock of materials (aggregate, emulsion, cement) for slurry seal mix. Measured quantities of material to prepare a batch of slurry seal mix shall be poured into the drum of the concrete mixture which shall then be rotated manually till an uniform mix of slurry seal is formed. The time of mixing shall be carefully controlled. Over mixing shall not be allowed as stripping of the bituminous film from the aggregate will occur. The slurry seal mix shall then be discharged over the road surface prepared as mentioned below.

(4) Surface Preparation for Slurry Seal

The road surface shall be broomed and cleaned of all loose or deleterious material by means of rotary broom and hand broom.

A tack coat shall be applied by an approved distributor or manually as directed by the Engineer at the rate to leave residual bitumen emulsion of 0.20 litre/sq.m. During spraying there shall be no ponding of binder in hollows or depression and any such excess of binder shall be removed. Portions of kerbs and channels, bridge kerb and railing which will be exposed, shall be suitably protected when applying tack coat.

(5) Application of Slurry Seal Mix

The slurry seal mix will be applied manually. The mix shall be spread uniformly over the road surface with the help of brooms, spades and other suitable tools so as to ensure that all cracks on road surface are properly filled and sealed and resulting surface becomes impervious to ingress of water. The application of slurry seal mix shall not be done in adverse weather condition as mentioned in Clause 1102.

Bituminous emulsion in drums shall not be allowed to freeze. In case where it is suspected that they could freeze then they shall be removed from site.

(6) Measurement

Slurry seal shall be measured in square metres.

(7) Payment

Slurry seal shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

2907. MAINTENANCE WITH SURFACE DRESSING

The work shall be done in conformity to Clause 1303, except that the use of small and portable equipment shall be permitted.

2908. MAINTENANCE WITH SAND SEAL

The works shall be carried out in conformity with Clause 1305, except that the use of small and portable equipment as well as labour based technique shall be permitted.

2909. MATINTENANCE WITH FOG SEAL

Fog seal shall consist of an application of emulsified bitumen without any aggregate cover for sealing the fine hair cracks like shrinkage cracks and alligator cracks.

(1) Material

Slow settingK3 - 60 bituminous emulsion shall be used.

(2) Application

The area to be applied with fog seal shall be thoroughly cleaned with compressed air, scrubbers etc. The cracks shall be cleaned with pressure air jet to remove all dirt, dust etc. The fog seal shall be applied at the rate of 0.5-0.9 litre/sq.m using equipment like a pressure tank, that with flexible hose and spraying bar. Traffic shall be allowed on the surface after the seal has set to a non tacky and firm condition so that it is not picked up by the traffic.

(3) Measurement

The fog seal work shall be measured in square meter.

(4) Payment

The fog seal work shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

2910. REPAIR OF BRICK SHOULDERS/FOOTPATHS

(1) Materials

Damages to the brick shoulders/foothpaths shall be repaired using materials of equal or higher standard than the original shoulders/footpaths materials.

(2) Construction

The damaged area shall be marked out in rectangular shape and shall be excavated with all sides vertical.

If the existing base/subbase is damaged it shall be excavated to the required depth and removed as directed by the Engineer.

The surface of the excavated surface shall be swept clean of dust and loose materials and shall be filled with base/subase and compacted. On the prepared base brick shall be laid in the same pattern as the adjoining surfaces and properly tamped.

The repaired surface shall be to the true profile to facilitate free drainage.

(3) Measurement

The brick shoulder/footpath repair work shall be measured in square meter.

(4) Payment

The quantity measured as above shall be paid at the contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 112.

SECTION 3000 – SUB-SURFACE GEOTECHNICAL INVESTIGATIONS

SECTION 3000 – MISCELLANEOUS WORKS

3001. SCOPE

For the design of foundation, the scope of subsurface exploration shall be to determine soil parameters and rock characteristics and their suitability by insitu testing or testing of samples/cores taken out of exploration. It shall be planned in such a way that the profiles of different types of soil and/or rock up to the desired depth for at least in the full length of the proposed bridge are recorded and other information such as physical/mechanical properties like grain size distribution, sensitivity, existence of deleterious materials, etc. in soil and/or ground water etc. are also determined.

3002. FIELD INVESTIGATION

Unless otherwise specified, the field investigation of subsurface shall be carried out in three phases, namely, Reconnaissance, Preliminary Explorations and Detailed Explorations.

(1) Reconnaissance

It shall include review of available topographic and geological information, aerial photographs and data from previous investigations and site examination.

(2) Preliminary Explorations

It shall include the study of existing geological informations, previous site reports, geological maps/aerial photos interpretations, and sub-surface geological examination. Geophysical investigations of the site shall also be conducted during this phase in order to have information about stratifications. Detail subsoil exploration shall be planned depending on these information.

Preliminary exploration shall be carried out to determine the soil profile showing the boundaries between the different types of soil and between loose and dense parts in the same type of deposits. For this purpose, as a first step, a suitable type of sub-surface sounding (e.g. static or dynamic cone penetration test) shall be carried out. As many soundings as necessary shall be made until penetration data is complete to provide the general shape and the trend of boundaries of the various soil deposits. Exploratory drill holes shall then be made at one or two locations where average condition prevails and near those points where the penetration diagrams indicate maximum deviations from the average.

(3) Detailed Explorations

The scope of the detailed exploration shall include boring programme based on data obtained after preliminary investigations. The bridge site, types of structure with span arrangement and the location & type of foundation shall be tentatively decided based on data obtained after preliminary investigations. Extent of explorations, number of boreholes, type of soundings, types and number of tests, open trial pits, etc., shall be decided for the execution of the exploration so as to collect adequate data considered necessary for the detailed design and execution of the related structure.

For bridge works, the investigations shall be comprehensive enough to enable the designer to estimate or determine the followings:

(a) the engineering properties of the soil and/or rock,
(b) the location and extent of soft layers under the hard founding strata,
(c) the geological condition like type of rock, faults, fissures or subsidence due to mining, porosity etc.,
(d) the ground water level,
(e) artesian conditions, if any,
(f) the location, type and extent of different layers,
(g) quality of water in contact with the foundation,
(h) probable settlement and probable differential settlement of the foundations,
(i) likely sinking or driving effort,
(j) likely construction difficulties,
(k) the depth and extent of scour,
(l) suitable depth of foundation, and
(m) bearing capacity of the foundation.

3003. METHOD OF EXPLORATIONS

Any of the following methods of exploration or their combination shall be used depending upon type of structure and strata.

(a) Geophysical Exploration
(b) Test/Trial Pits
(c) Boring
(d) Static Cone Penetration Test
(e) Dynamic Cone Penetration Test
(f) Plate Load Test
(g) In-situ Vane Shear Test

(1) Geophysical Exploration

Use of geophysical methods shall be limited to the detection of voids, buried channels or rock mass classification.

The two main geophysical methods to be used shall be:

(a) Electrical Resistivity Method.
(b) Seismic Method.

(2) Test/Trial Pits

Test/trial pits shall be used for direct visual examination of the soil and its stratification including water table. This will also allow for the execution of in-situ tests like plate bearing tests, shear tests, etc. A test/trial pit shall be at least 1 m square at the bottom of the pit. The depth of the pit shall be 3 m, unless otherwise specified. Below a depth of about 1.5 m, the sides of the pit shall be supported or shall be excavated at safe angle. Pits shall be left open for some time so 1I1at seepage lines on the sides of the pit can be examined and the existing ground water level can be indicated.

(3) Borings

Boring a hole shall be started by driving casing to prevent it from caving in. Casing shall be cleaned by means of chopping bit, etc., with the water pumped through drill rod and water overflows at the top carrying soil particles. The hole shall be advanced by raising, rotating and dropping the bit into the soil at the bottom of the hole. In rotary boring, drill bit shall be rotated with the simultaneously application of pressure to advance the hole. In case where sample disturbance is not critical, hand or powered auger boring can also be carried out with the prior approval of the Engineer.

(A) General Requirements of Boring/Drilling

The equipment for boring shall be automatic hydraulic or mechanical feed with properly working indicator of drilling pressure. The equipment shall be with transmission gear to adjust spindle speed. The Contractor shall supply all necessary flush water for the execution of boring and pertinent tests. Clear water shall only be used. Nevertheless, the equipment shall be capable of handling mud flush.

The barrels for boring shall be double tube core barrel. Only in certain circumstances, use of single tube core barrel shall be allowed.

The drilling machine shall be equipped with different sizes of casings in order to allow proper telescoping of definite sizes. The final diameter of the borehole shall be such that allows extraction of samples with proper dimension in order to properly conduct tests, such as consolidation, shear, triaxial, permeability, etc.

(B) Methods of Boring

Boring shall be done by any of the methods mentioned below depending on the soil type and types of samples required for the investigation.

(a) Auger Boring (Manual and Mechanical)
(b) Percussion Boring
(c) Wash Boring
(d) Rotary Boring

(a) Auger Boring

(i) Hand Auger Boring

In the hand auger boring method, light hand operated equipment shall be used. The auger and drill rods shall be lifted out of the borehole without the aid of a tripod and no borehole casing shall be used. Boreholes up to 200 mm diameter shall be made in a suitable ground condition up to a depth of about 5.0 m. Hand auger boreholes shall be used for ground water observations and to obtain disturbed samples and small tube samples.

(ii) Mechanical Auger Boring

Small portable power augers, shall be suitable for boring to depth of 10- 15 m. The hole diameter shall be in the range of 75 to 300 mm.

(b) Percussion Boring

Adaptation of standard boring methods shall be suitable for soil and weak rock. The size of the borehole casing and tools shall generally be 100 mm, 150 mm, 250 mm and 300 mm giving a maximum borehole depth of about 60 m in suitable strata. The drill tools, hooked on a wire rope using the clutch of the winch for the percussion action, shall be a clay cutter for dry cohesive soils, a shell or baler for cohesion less soils and a chisel for breaking up rock and other hard layers. The clay cutter and shell shall bring up disturbed material for laboratory testing and identification of strata.

(c) Wash Boring

Wash boring shall be carried out as per IS ,BS , ASTM or equivalent standard.

(d) Rotary Drilling

In rocky strata rotary drill shall be used. Open hole drilling, in which the drill bit cuts all the material within the borehole, shall be used for more rapid progress in hard material. Better quality samples of soil and rocks shall be obtained using core drilling, in which an annular bit fixed to the bottom of outer rotating tube of a

rotary core barrel cuts a core, which is retained within the inner stationary tube of the core barrel and brought to the surface for examination and testing.

(C) Size of the Borehole for Sampling

Rotary drills and/or percussion drilling shall be used for getting undisturbed soil sample. The size of casing shall be sufficient to provide space for retrieving undisturbed sample by sampler tube for soil. For rock sample, the size of casing shall be sufficient enough to allow use of single or double tube barrel as required for retrieving core sample.

(D) Condition of Boring

While conducting detailed borings, the resistance to the speed of drilling i.e. rate of penetration, core loss, etc., shall be carefully recorded to evaluate the different types of strata and to distinguish specially sand from sandstone, clay from shale, etc.

For good coring either in soil or in rock, the driller shall carefully watch and record the speed of the rate of cutting of bit, bit pressure, bit feed, pump pressure and discharge.

(E) Extent of Boring

The depth of boring shall depend upon the type of proposed structure, its total weight, and type of subsoil encountered. Normally tests shall be taken down below the foundation level depending upon the type of foundation e.g.

(a) foundation requiring shallow depth: up to a depth: where the magnitude of stress due to the structure load is equal to 10% of the overburden pressure, but at least one boring shall be made deep enough preferably up to hard strata or rock to ascertain the existence of any exceptionally compressible stratum that are unsuitable for foundation

(b) for rock foundation: until sound bed rock is reached and confirmed by at least 3 m coring by rotary drilling. In sound bed rock more than 6m drilling may not be required. In residual profile it may be necessary to drill further 3 m to differentiate rock from drill bit the boulder.

The spacing of borings shall be such as to reveal any major changes in the thickness, or properties of the strata over the base area of the structure and in its immediate vicinity.

A preliminary estimate of spacing may be modified depending upon the information revealed by boring. The Boring Agency shall notify the Engineer the situation and shall seek his approval for such modification(s).

(F) Records of Test/Trial Pits and Borings

For all test/trial pits and borings, general information as detailed below shall be given. A site plan showing the position of the bore holes/trial pits shall also be attached.

(i) Boring Company
(ii) Location with reference map
(iii) Pit /Bore -hole number
(iv) Reduced level (R.L.) of ground surface or other reference point with arbitrary permanent Bench Marks
(v) Dates of starting and completion
(vi) Name of supervising engineer and driller
(vii) Dimensions and methods of advancing exploration
(viii) Any other information and remark including weather/climatic condition, difficulties encountered, etc.

(G) Bore Hole Log

The final bore hole tog shall be based on the visual examination, description of the samples, laboratory test results, driller's daily report forms and geology of the site. All the relevant data collected by the driller, once checked and amended where necessary, shall be recorded. The bore hole log shall be maintained in the format shown in Appendix 30.1

The bore log shall contain the elevation at which the water table and the upper boundary of each of the successive soil strata were encountered, the investigator's classification of the layer on the basis of general information obtained from field examination and the value of the resistance obtained by means of Standard Penetration Test (hammer wt.65 kg & falling height 75 cm for rotary drilling attached with standard split barrel sampler at the bottom connected with drill rod) or Static Cone Penetration as specified. The type of tools used for boring shall be recorded. If the tools were changed, the depth at which the change was made and the reason thereof shall also be noted. Incomplete and abandoned borings shall be described with no less care than successfully completed drill holes. The notes shall contain

everything of significance observed on the job, such as the elevation at which wash water was lost from the hole, etc. All field and final logs shall be signed by the supervising Engineer.

(H) Sample Core Recovery and Core Boxes

Only samples that are unaltered and not damaged by drilling process shall be considered as core. Core drill shall be so designed that in sound rock, continuous recovery is achieved. Run shall be short in order to achieve maximum core recovery. Where there is core loss, it shall be noted on field borelog. It shall be shown by placing wooden stick in the core box so that Engineer can judge how much core has been achieved.

For getting disturbed soil (granular) sometime water is circulated down the hollow rods which returns outside them, carrying the rock cutting to the surface as sludge. These shall be retained as samples in transversing friable rock where cores cannot be recovered. It shall be ensured that boulders or layers of cemented soils are not mistaken for bedrock. For laboratory determination of uniaxial compressive strength of rock materials, the final size or dimensions (minimum) of the specimen shall be after trimming in the form of circular cylinder having height to diameter ratio of 2.5 to 3.0 and the diameter of core shall not be less than 54.7 mm.

Sufficient quantity of core boxes shall be available at site before the commencement of boring. Further drilling works shall be stopped if it is found that boring is carried out without core boxes and undisturbed sampler tube.

The core box shall be made of good and durable material. The boxes shall bear lids and hinges. The files inside the core boxes shall have a length of 1.05 m.

Cores shall be placed in core boxes in a proper order and direction. The end of each core run shall be marked by a cross piece with indication of depth. The box shall provide information on borehole, depth of corresponding core, number of box etc. The coreboxes shall be transported to the location instructed by the Engineer. The provided core with coreboxes shall be available for inspection as and when required by the Engineer. The boxes shall be the property of Department of Roads.

The cores shall be carefully extracted out of the core barrel and placed in core boxes. Core shall correspond each time to the fixed depth with accuracy of 1 cm.

A minimum core recovery of 80 % in hard rock and 50 % in other strata (except sand strata) shall be achieved. If possible none or

minimum quantity of water shall be added while boring through soft cohesive soils and cohesionless soils above water table in order to maintain its natural moisture content and stress condition for further in-situ and laboratory tests.

(I) Sampling

There shall be two types of samples, (a) Disturbed sample and (b) Undisturbed sample. The usual methods for sampling shall be as stated below.

(i) Disturbed Sample

(a) Soil

Types of disturbed samples shall be:

- Hand Samples
- Auger Samples
- Sludge Samples
- SPT Sample
- Sample Extracted from Barrel

Disturbed samples shall be obtained in the course of excavation and boring. For taking samples from below the ground water level, special type of sampler shall be used. Where standard penetration test is conducted, representative samples shall be obtained from the split spoon.

Quantity of samples required for laboratory testing shall not be less than as shown in Table 30.1.

Table 30.1: Required Quantities of Samples

S.No.	Purpose of sample	Soil type	Wt. of sample (kg)
1	Identification, Natural moisture content, Mechanical analysis and index properties	Soil	2
2	Identification, Natural moisture content, Mechanical analysis and index properties	Sand	5
3	Identification, Natural moisture content, Mechanical analysis and index properties	Fine to medium type of gravel	5
4	Identification, Natural moisture content, Mechanical analysis and index properties	Coarse gravel	30

(b) Rock

The sludge from percussion borings or rotary borings which have failed to yield a core, shall be collected as disturbed

samples. It may be recovered from circulating water by settlement in a trough.

The types of disturbed samples shall be:

- Wash Samples from Drilling
- Sludge Samples

(ii) Undisturbed Sample

(a) Soil

Samples shall be obtained in such a manner that moisture content and structure do not get altered. This shall be ensured by careful use of correctly designed sampler, protection and packing.

Type of undisturbed sampling sampler shall be as follows:

A. Block sampling (Hand Samples) shall be carried out by manual excavation inside the trench or pit.

B. Thin-walled Sampler Tube: for soft and firm soils (internal diameter 75mm to 250 mm)

C. Open Tube Sampler: for firm to stiff clays, disturbed samples for weak rock (100mm diameter open tube sampler, like U100)

D. Stationary Piston Sampler: for soft sensitive clays, noncohesive fine grained soil and firm to stiff soils not containing coarse material.

E. Sand Sampler: for silts and sands below the water table (like Bishop sand sampler)

For compression test, samples of 40 mm diameter and 150 mm to 200 mm length may be sufficient, but for other laboratory tests, samples of 100 mm diameter and 300 mm length shall be taken unless otherwise instructed by the Engineer.

While preparing samples the upper few millimeters of sample shall be removed.

(b) Rock

A. Block samples: Such samples taken from the rock formation shall be dressed to a size about 90x75x50 mm.

B. Core samples: Cores of rock shall be taken by means of rotary drills fitted with a coring bit with core retainer and the diameter of core shall be as mentioned in Sub-clause 3003 (3) (H).

Frequency of sampling shall be at every change in stratum and at intervals not exceeding 1.5 m within a continuous stratum.

(J) In situ Test on Boreholes

In course of boring works, in situ test as mentioned below shall be carried out for the determination of bearing capacity. Other tests like permeability, etc. shall also be se of carried out as directed by the Engineer. In particular, following tests shall be conducted:

(i) Standard Penetration Test (SPT)
(ii) Vane Shear Test
(iii) Insitu Deformation Properties and Strength Measurements from a borehole using Pressuremeter.
(iv) Other tests as applicable.

Where undisturbed soil sampling, in-situ vane shear test and SPT are to be carried out in one layer, the sequence shall be undisturbed soil sampling followed by in situ vane shear test and SPT.

(K) Protection, Handling and Labeling of Samples

Care shall be taken in handling, labeling and transportation of samples so that they shall be received in an acceptable state for identification, examination and testing.

The disturbed material in the upper end of the tube shall be completely removed before applying wax for sealing. The length and type of sample so removed shall be recorded.

The soil at the lower end of the tube shall be reamed to a distance of about 20 mm. After cleaning, both ends shall be sealed with wax applied in a way that shall prevent wax from entering the sample. Wax used for sealing shall not be heated to more than a few degrees above its melting temperature. The empty space in the samplers, if any, shall be filled with moist soil, saw dust etc., and the ends shall be covered with tight fitting caps.

(4) Static Cone Penetration Test

This test shall be carried out for deep foundation of bridges for cohesive soil according to the stipulations of IS: 4968 (Part 3) or equivalent standard.

(5) Dynamic Cone Penetration Test

This test shall be carried out as per IS: 2131. Wherever applicable, this test shall also be carried out as per IS: 4968 (Parts 1 &2).

(6) Plate Load Test

For cohesion less soil in deep foundation, plate load test shall be carried out as per IS: 1888.

(7) In-situ Vane Shear Test:

Vane shear test shall be conducted as per IS: 4434 on cohesive soil for deep foundation.

(8) Exploration for Foundation Resting on Rock

The basic information to be obtained from the exploration shall be as follows:

(i) Depth of Rock strata and its variation over the site
(ii) Whether isolated boulder or massive rock formation,
(iii) Extent & character of weathered zone
(iv) Structure of rock- including bedding planes, faults, fissures, solution cavities etc.
(v) Properties of rock material strength, geological formation etc.
(vi) Erodibility of rock to the extent possible.
(vii) Colour of water/sludge

(9) Exploration for Foundation Resting on Rock

The investigation shall be generally to that required for rock. The samples collected shall be subjected to suitable tests depending upon the material. Care shall be taken to ascertain erodibility of the matrix . For shallow foundation, Plate Load Test shall be conducted.

(10) Investigation for Laterites

The investigation shall be generally similar to that required for cohesive soils, use of penetration tests shall be preferred if suitable correlation charts are available. This may be static or dynamic penetration tests or vane shear tests. In the case of hard laterite, recourse may have to be made to core drilling as for soft rocks. For laterites at shallow depths, Plate Load Test shall be conducted.

(11) Supervision of the Work

The supervision of the work shall be the carried out by a qualified and experienced Engineer.

3004. LABORATORY TESTING

The driller shall be experienced and also responsible for recording the information obtained from the bore hole.

Laboratory tests shall be carried out on disturbed, undisturbed samples and on rock extracted by pitting or boring as per requirements for the related type of structure. Tests shall be carried out among the followings as per contract or as directed by the Engineer:

- Grain Size Analysis
- Hydrometer Analysis
- Bulk and Dry Density
- Specific gravity
- Natural Moisture Content
- Atterberg's Limit Tests
- Unconfined Compression Test
- Consolidation Test
- Direct Shear Test
- Sulphate and Chloride test
- Vane Shear Test
- Point Load strength test on rock
- Uniaxial compressive strength Test
- Triaxial Tests:
  - Unconsolidated Undrained Test
  - Consolidated Undrained Test

The above test shall be carried out as per Section 600 of these Standard Specifications.

3005. WATER SAMPLES

If a trial pit has been excavated or a well exists near the site of exploration, water samples shall collected. In the case if boring, it shall be collected from the borehole with the help of a common suction pump having a hose pipe, rubber tubing etc. which can be conveniently lowered down into the borehole connected at the suction end. Minimum 5 lit. of water sample shall be collected into a clean vessel and sent to the laboratory for chemical tests. Tests shall be carried out in accordance with IS: 3025 or equivalent stanpard as per direction of the Engineer.

3006. CONCLUSIONS AND RECOMMENDATIONS

The investigation shall conclude with the recommendation for the proper type of foundation for the related structure. The recommendation shall be supported by all details of investigations and their results

3007. MEASUREMENT

Boring in rock and/or soil shall be measured separately in linear metre with reference to the ground level in the following multiples:

(a) from ground level upto 3.00 m of depth
(b) from 3.00 m upto 6.00 m of depth
(c) from 6.00 m upto 9.00 m of depth
(d) from 9.00 m upto 12.00 m of depth
(e) from 12.00 m upto 15.00 m of depth
(f) from 15.00 m upto 18.00 m of depth
(g) from 18.00 m upto 21.00 m of depth
(h) from 21.00 m onward in the multiple of 1 m of depth

Trial pits shall be measured in cubic metres. Collection of disturbed and/or undisturbed samples including provision for transportation and storing of core boxes shall be measured in number. Each type of tests shall be measured in number. Mobilisation, demobilisation and shifting of equipment from one borehole to other borehole shall be measured separately.

3008. PAYMENT

Boring, trial pits, collection of samples, testing of samples and submission of reports in required number shall be paid at their respective contract unit rates which shall be the full and final compensation to the Contractor as per Clause 112 and also for the cost of all other operations and incidental works deemed necessary to complete the work as per the these Specifications.

Mobilization, demobilization and shifting of equipment from one borehole to other borehole shall be paid separately on lump sum basis.

APPENDIX 30.1: BORE HOLE LOG SHEET

Project:	Date Started:
Client:	Date Completed:
Consultant	Surface elevation:
Location	Sheet no.:
Investigation for:	Drilling Machine:
Drill Hole No.:	Drilling method:
Depth at which Undisturbed sample taken:	Diameter of UD Sample:
Total no. of undisturbed sample taken:	

Date	Drill run length (m)		Core recovery (%)	Casing		Flush return	Water level (m)	SPT			Litho-logy	Soil/Rock Description
	From (m)	To (m)		Hole size	Depth (m)			0-15	15-30	30-45		

Drilled by: Site Incharge: Logged by: Client Representative:

SECTION 3100 – MISCELLANEOUS WORKS

SECTION 3100 – MISCELLANEOUS WORKS

3101. SCOPE

This Section cover the works related to the construction of miscellaneous works such as precast members, joints, wearing coat on drainage structure, railings, approach slab, drainage spouts and weep holes. These miscellaneous works are to be constructed in connection with the structures.

3102. PRECAST MEMBERS

(1) Materials

Concrete and reinforcement for precast members shall comply with Section 2000.

(2) Placing Pre-cast Member

Pre-cast concrete members shall be placed in the structure in conformance with the Drawing and any special provisions for the structure to be constructed. Extreme care shall be exercised in handling, storing and erecting pre-cast reinforced or pre-stressed concrete members to avoid twisting, racking or other distortion that would result in cracking or damage to the members. Pre-cast members shall be handled, transported and erected in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same as when the member is in it's final position.

(3) Measurement

Depending upon the nature of works, pre-cast members shall be measured in numbers, cubic meters or metric tonnes as specified in the Contract. Reinforcement shall not be measured for payment.

(4) Payment

The quantities measured as provided above shall be paid at the contract unit rate applicable for the particular type of work. The contract unit rate shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.

3103. OPEN JOINT, FILLED JOINTS, BOARD FILLERS AND SHEET PACKING

(1) Open Joints

Open joints shall be constructed at the locations shown in the Drawing using suitable stops, which are to be subsequently removed. When removing the

material, care shall be exercised to avoid chipping or breaking the corners of the concrete. The edges of the concrete, at the joints, shall be properly finished. Reinforcement shall not extend across an open joint, unless otherwise shown on the Drawing.

(2) Filled Joints

When pre-moulded joint filler or expanded polystyrene joint filler or other type of joint filler is shown on the Drawing or specified, the filler shall be placed in correct position before concrete is placed against the filler. Holes and joints in the filler shall be filled with mastic to prevent the passage of: mortar or concrete from one side of the joint to the other. The edges of the concrete, at the joints, shall be properly finished. When shown on the Drawing, water stops shall be placed. Unless otherwise specified the joint filler shall have the prior approval of the Engineer.

(3) Board Fillers

Hardboard joint filler shall be minimum of 3mm thick and approved by the Engineer. Expanded polystyrene board shall have a minimum flexural strength of 0.25 N/sq.mm. and a compressive yjeld strength of 0.11 N/sq.mm. minimum and 0.28 N/sq.mm maximum at 5% compression. Vertical faces of polystyrene against which concrete is to be placed shall be faced with hardboard of 3mm minimum thickness or other equivalent material. Other board fillers may be used with the approval of the Engineer. All board fillers shall be held in place with nails, a waterproof adhesive or other means approved by the Engineer.

(4) Sheet Packing

Asbestos sheet packing shall have the approval of the Engineer. It shall be approximately 1.6 mm thick unless otherwise shown on the Drawing or specified in the contract and shall be composed essentially of asbestos firbres bound together with a cementing medium rendering it tough and pliable. One side shall be coated with graphite. The deformation of the packing under a load of 70 N/sq.mm shall not be more than 16% and the loss on ignition shall not be more than 25%. When tested between planed bronze plates under a load of 5 N/sq.mm the 3' packing shall show a static coefficient of friction of less than 0.4 after 100 lateral movements at 6.5mm.

(5) Measurement

Open joints, filled joints, board fillers and sheet packing shall not be measured separately.

(6) Payment

No separate payment for open joints, filled joints, board fillers and sheet packing shall be made. The cost of such joints is deemed to be included in the unit rate of the structures, where those joints are required to be formed.

3104. WEARING COAT

(1) Bituminous Wearing Coat

The wearing coat shall be the asphalt concrete/surface dressing and shall comply with Section 1300.

(2) Cement Concrete Wearing Coat

Cement concrete wearing coat shall be provided in case of isolated drainage structures constructed at those locations where the road is not being asphalted or the drainage structures the, are not proposed to be asphalted. It shall not be laid monolithic with the deck. Concrete shall comply with Section 2000.

The thickness of wearing coat shall be 75 mm. The minimum grade of concrete shall be M 30/20 with water cement ratio of 0.4.

Curing of wearing coat earlier than what is generally required may be resorted to, so as to avoid formation of shrinkage cracks in hot weather.

All carriageway and footpaths surface shall have non-skid characteristics.

The cross slope in the deck shall be kept as 2.5 percent. For providing cross camber no variation in thickness of wearing coat shall be permitted.

(3) Measurement

Wearing coat shall be measured as provided under respective sections of these specifications.

(4) Payment

Wearing coat shall be paid as provided under respective sections of these specifications.

3105. RAILINGS

(1) General

(a) Railing includes the portion of the structure erected on and above the kerb or slab for the protection of pedestrians and traffic as shown on the Drawing.

(b) Railings shall not be constructed until the false work for the span has been released. For concrete with steel reinforcement, specifications of the items of concrete and reinforcement mentioned under relevant Sections of these Specifications shall be applicable.

(c) Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 0.2%. The pockets left for posts shall be filled up with the concrete of the same grade as the post.

(d) The type of railing to be constructed shall be as shown on the Drawing.

(e) Expansion joint in the railings shall be maintained to ensure proper functioning of the joint.

(f) Railing materials, particularly metal railings, shall be handled and stored with care, so that the material and parts are kept clean and free from damage. Railing materials shall be stored above the ground on platforms, skids or other supports and kept free from grease, dirt and other contaminants.

(2) Steel Railings

Materials, fabrication, transportation, erection and painting for railings shall conform to the requirements of Section 2200.

All complete steel rail elements, pipe terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanised or painted with an approved paint as specified in the Contract.

If galvanised, all elements of the railing shall be free from abrasions, rough or sharp edges, and r shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer.

Galvanising shall be carried out as per Clause 2209. Damaged galvanised surfaces, edges of holes and ends of steel railing cut after galvanising shall be cleaned and re-galvanised.

The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure to the true grade and alignment.

Unless otherwise specified in the Drawing, metal railing shall be given one shop coat of paint and three coats of paint after erection if sections are not galvanised.

Steelwork which is to be cast or grouted into concrete shall be unpainted and shall be cleaned of loose rust, scale, oil and other material which may impair the bond between concrete and steel.

When shown on the Drawing, the rail elements shall be curved before erection.

(3) Cast-in-Situ Concrete Railings

The portion of the railing or parapet, which is to be cast in place, shall be constructed in accordance with the requirements of Section 2000.

Forms shall either be of single width boards or shall be lined with suitable material duly approved by the Engineer. Form joints in plane surfaces shall not be permitted.

All mouldings, panel work and level strips shall be constructed according to the details shown on the Drawing. All corners in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects. Casting of posts shall be done in single pour.

(4) Pre-cast Concrete Railings

Pre-cast members for railings shall be of reinforced cement concrete and shall conform to the specifications given in Section 2000. The maximum size of the aggregate shall be limited to 12 mm and the concrete grade shall be M30. The pre-cast members shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days. During this period they shall be protected from sun and wind. Any pre-cast member that becomes chipped, marred or cracked before or during the process of placing shall be rejected. Care shall be taken to watch the surface of the cast-in-situ portion of the deck. Railing shall be erected to the true line and grade with a tolerance not exceeding 0.2% in anyone pannel.

(5) GI Pipe Railing with RCC Posts

(a) GI Pipe

GI pipe shall comply with NS: 199/2046 (Heavy Duty).

All GI pipes shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. Any pipe which does not meet the requirements of the field Specifications shall be replaced at the Contractor's expense.

(b) RCC Posts

The concrete grade and type of reinforcements for concrete posts shall be as indicated in the Drawing. The specifications for concrete and reinforcements shall be as provided under Section 2000.

(6) Measurement

Railings shall be measured in linear meter of railing installed and accepted. Railing shall include both horizontal and vertical members, posts including bolts, nuts, fittings etc.

(7) Payment

Railing, measured as provided above, shall be paid at the contract unit rate. The contract unit rate shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.

3106. APPROACH SLAB

(1) General

Reinforced concrete approach slab shall be provided at both ends of the drainage structure as shown on the Drawing. The width, length and depth of the slab shall be as shown on the Drawing. The minimum grade of concrete for approach slab shall be M20/40.

The gap between the approach slab and superstructures shall be watertight by filling the gap with approved joint filler. The type and thickness of the base of approach slab shall be as shown on the Drawing and shall be constructed as per the requirements of Section 1200. The concrete and reinforcements shall conform to Section 2000.

(2) Measurement

Approach slab and its base shall be measured separately in cubic meters.

(3) Payment

The quantities measured as provided above shall be paid at the respective contract unit rates. The contract unit rates shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.

3107. DRAINAGE SPOUTS

(1) Maintenance and General Requirements

Drainage along longitudinal direction shall be ensured by sufficient number of drainage fixtures (spouts) embedded in the deck slab. The spouts shall be of not less than 100 mm in diameter and shall be of heavy coated galvanised steel with suitable clean out fixtures or as shown on the Drawing. Steel components shall be of mild steel conforming to IS: 226. The spacing of drainage spouts shall not exceed 3m and shall be in staggered pattern. The discharge from drainage spout shall be kept away from the deck structure. In case of viaducts in urban areas, the drainage spout shall be connected with suitably located pipelines to discharge the surface run-off to drains provided at ground level.

(2) Fabrication

The drainage assembly shall be fabricated to the dimensions shown on the Drawing. The drainage assembly shall be seam welded for water tightness and then hot-dip galvanised

(3) Placement

The whole assembly shall be placed in true position, lines and levels as shown on the Drawings with necessary cut-out in the shuttering for deck slab and held in place firmly. Where the reinforcements of the deck are required to be cut, equivalent reinforcements shall be placed at the corners of the assembly.

The galvanised pipes of drainage spouts shall be extended beyond the concrete/metallic beams/slabs in such a way that the water from the pipes does not damage them.

(4) Finishing

After setting of the deck slab concrete, the shrinkage cracks around the assembly shall be totally sealed with polysulphide sealant or bituminous sealant as per 18:1834 and the excess sealant trimmed to receive the wearing coat. After the wearing coat is completed, similar sealant shall be finished to cover at least 50 mm on the wearing coat surface all round the drainage assembly.

(5) Measurement

Drainage spouts shall not be measured separately. No deduction in concrete volume shall be made for drainage spouts.

(6) Payment

Drainage spouts shall not be paid separately. The contract unit rate for concrete shall be deemed to include costs for forming such spouts.

3108. UTILITY FACILITIES

(1) General

Utility facilities shall be carried in or on structures as shown on the Drawing or described in the Contract. These facilities may be installed by the authorities concerned or by the Contractor as described in the Contract or indicated on the Drawing.

(2) Provision and Installation

Hangers, anchor bolt inserts, manhole frames and covers, sleeves and other accessories required for such facilities, which must be cast in the concrete shall be furnished by the respective authorities or the Contractor as described in the contract and shall be installed by the Contractor in accordance with the details shown on the Drawing or as directed by the

Engineer. Utility facilities which require installation after the concrete has been cast and before other construction is in place which would interfere with it's installation, will be installed, either by the authorities concerned or by the Contractor as directed by the Engineer at such times as the work is ready for their installation. The Contractor shall notify the Engineer in writing at least 30 days in advance of the proposed dates, that the work will be ready for installation of ere accessories of utilities in the structure. The Engineer, in turn, shall make necessary arrangements with the utility authorities.

(3) Measurement

Unless otherwise provided in the Contract, utility facility shall not be measured separately.

(4) Payment

Unless otherwise provided in the Contract, utility facility shall not be paid separately. The cost of utility facility shall be deemed to be included in the unit rates of different items of work of structure.

3109. WEEP HOLES

(1) Weep holes

Weep holes shall be provided in solid plain concrete/reinforced concrete, brick/stone masonry, abutment, wing wall, return walls or other structures as shown on the Drawing or as directed by the Engineer. Weep holes shall be provided with 100mm dia polythene pipe for structures in plain/reinforced concrete or brick masonry. In case of stone masonry, weep holes shall be 100 mm wide, 100 mm high or circular with 100 mm diameter. Weep holes shall extend through the full width of concrete/masonry with a slope of 1 vertical 20 horizontal towards the draining face. The spacing of weep holes shall generally be 1 m in either direction or as shown on the drawing with the lowest at about 150 mm above the low water level or ground level whichever is higher or as directed by the Engineer. Surfaces of the weep holes shall be smooth and it shall be ensured that the water is properly driven from the backfill.

(2) Measurement

Weep holes shall not be measured separately. No deduction in the volume of structures shall be made for weep holes.

(3) Payment

Weep holes shall not be paid separately. The contract unit rate for respective items shall be deemed to include costs for providing such holes.

3110. FILTER MATERIALS

(1) Materials

Filter materials shall be either gravel with geo-textile/geo-membrane or appropriately graded sand/gravel material as shown on the Drawing or directed by the Engineer.

Where geo-textile/geo-membrane is provided or shown on the Drawing, the filter material shall consist of gravel. It shall conform to the grading limits set out in Table 31.1.

Table 31.1: Filter Material Grading Limits

Sieve Size (mm)	Percentage Passing by Wright
63	100
37.5	85-100
20	0-20
10	0-5
0.075	-

Geotextile shall comply with Section 600. Geomembrane shall comply with Sub-clause 2404 (2).

Where no geotextile/geomembrane are provided or shown on the Drawing, the grading curve required for sand/filter material shall be determined for each site. Grading criteria requirement for both underlying and overlying material shall be fulfilled. The criteria shall be as follows:

a) $\frac{d_{15\%}\ \text{filter}}{d_{85\%}\ \text{subgrade}} < 5$ b) $\frac{d_{50\%}\ \text{filter}}{d_{50\%}\ \text{subgrade}} < 25$

b) $\frac{d_{15\%}\ \text{filter}}{d_{15\%}\ \text{subgrade}} > 5$

Where, d15% designates the 15% size of the material (i.e. the size of the sieve that allows 15% by weight of the material to pass through it).

Similarly, d50% and d85% designate the sizes of sieve that allow 50% and 85% respectively by weight of the material to pass through it.

(2) Construction

Surfaces receiving geo-textile/geo-membrane shall be free of loose or extraneous materials and sharp objects. Geo-textile/Geo-membrane shall be placed in accordance with the producer's instructions or as instructed by the Engineer. The minimum overlapping shall be 450 mm. If jointed in longitudinal direction by sewing or gluing, the joint shall have the same strength as the fabric itself.

The filter material shall be compacted layer by layer to a minimum density of 93% of the MDD (Heavy Compaction).

(3) Tests and Standard of Acceptance

Copies of manufacturer's certificate for geo-textile/geo-membrane to be used shall be furnished by the Contractor. In addition, the Engineer may ask for testing in independent laboratories. All test results shall meet the specified requirements.

Minimum one set of test for gradation and compaction of filter material shall be executed for every 50 cu.m. and every change in source of material. The results shall meet the specified requirements.

(4) Measurement

Geo-textile/Geo-membrane shall be measured in square meter. Overlapping shall not be measured for payment. Filter material shall be measured in cubic meter. No separate measurement of geo-textile/geo-membrane and filter material shall be done in case of sub- surface and drilled sub-surface drains.

(5) Payment

Geo-textile/Geo-membrane and filter material measured as provided above shall be paid the respective contract unit rates which shall be the full and the final payment to the Contractor as per Clause 112 to complete the work as per these Specifications.