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ROYAL GOVERNMENT OF BHUTAN
MINISTRY OF WORKS & HUMAN SETTLEMENT
DEPARTMENT OF ROADS

Double Lanning of Northern East West Highway



TECHNICAL SPECIFICATIONS
FOR THE
DOUBLE LANNING OF
NORTHERN EAST WEST HIGHWAY

ABBREVIATIONS

The following abbreviations are used in the Technical Specifications.

AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ALD	Average Least Dimension
ASTM	American Society of Testing and Materials
BOQ	Bill of Quantities
BS	British Standards
BSR	Bhutan Schedule of Rates
CBR	California Bearing Ratio
c/c	center to center
Cu.m	Cubic metre
CR	Crushing Ratio
DCP	Dynamic Cone Penetrometer
DoFS	Department of Forestry Services
DoR	Department of Roads
DGM	Department of Geology and Mines
Dia	diameter
ECOP	Environment Code of Practice for Highways and Roads
EMP	Environmental Management Plan
FI	Flakiness Index
GCC	General Conditions of Contract
HMAC	Hot mix asphalt concrete
IRC	Indian Road Congress (i.e. Recommended Code of Practice by IRC)
IS	Indian Standards
ISO	International Organization for Standardization
LAA	Los Angeles Abrasion Value
LS	Linear Shrinkage
MC	Moisture Content
MDD	Maximum Dry Density
min	minute
NEC	National Environment Commission
No	Number (units), as in 6 no.
No	Number (order) as in No 6
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PCC	Particular Conditions of Contract
PI	Plasticity Index
PL	Plastic Limit
PM	Plasticity Modulus (PI x % passing 0.425 mm sieve)
QA	Quality Assurance
PS	Provisional Sum
QC	Quality Control
RGoB	Royal Government of Bhutan

RROW	Road 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
Sq.m	Square metre
UC	Uniformity Coefficient
UCS	Unconfined Compressive Strength
VIM	Voids in Mix
w/c	Water cement ratio
Wt	Weight
%	Percent



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101 GENERAL

The Technical Specifications (TS) and Bill of Quantities (BoQ) shall be read in conjunction with all other Contract Documents. All the documents and drawings are to be regarded as mutually explanatory. In the event of any discrepancy or assumed discrepancy being found between them, the Contractor shall immediately inform the Engineer of the matter in writing and the Engineer will issue instructions in the matter in accordance with the Conditions of Contract including the Environmental Codes of Practice for Highways and Roads and other relevant references/codes.

The terminology “Engineer” in these Technical Specifications shall be read or understood as Project Manager/Project Engineer of the Regional Office, DoR, Lingmethang.

The Sections, Clauses and/or Sub-clauses mentioned in these Specifications deem to apply those of these Specifications only, if otherwise not specified. The Specifications or Technical Specifications shall denote the same meaning of the specifications.

102 PROGRAM OF WORKS

As soon as possible after the letter of acceptance, the Contractor shall submit in *triplicate* the Program and particulars required under Clause 27 of the General Conditions of Contract (GCC). The Contractor shall provide all information needed for fulfilment of the Program and required in accordance with the Conditions of Contract including the sequence in which the Contractor intends to work including implementation of quality assurance plan. In the Program and particulars the Contractor shall provide details of how the Contractor proposes to carry out the Works including:

- (1) The Program for the construction and completion of the works shall be established using CPM/PERT techniques or equivalent. The Program shall be detailed enough to give, in addition to construction activities, detailed network activities for the submission and approval of materials, procurement of materials, procurement/rental/leasing of equipment, progress milestones, fabrication of special products/equipment if any and their installation and testing, and for all activities of the Engineer that are likely to affect the progress of work. It shall be prepared so as to permit revisions, inclusion of additional detail and regular updates as the work progress. The Program shall also include the Contractor's general requirements for any road closures pursuant to Clause 105 of the Technical Specifications 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. In all respects the Contractor shall pay particular attention to seasonal weather pattern including rainfall and snow conditions (if any), and the construction sequencing while preparing the Program and executing the Works. Any proposal for night working shall also be stated in the Program.
- (2) A detailed Statement of Construction Management Procedures the Contractor proposes to adopt.

Once approved by the Engineer the Program and Statement of Construction Management Procedures shall be incorporated into the Contract Agreement and shall be strictly adhered to unless any alterations are found to be necessary during the construction of the Works and are confirmed in writing by the Engineer. If the Contractor requests a change in the sequence and such change is approved by the Engineer, the Contractor shall have no claim as per the Conditions of Contract for delay arising from such revisions to the Program.

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 Contractor shall furnish, at least 14 days in advance, his site work program of commencement of item of work, the method of working he intends to adopt for various items of work such as site clearance, construction for embankment, sub-base, base, surfacing, culverts, retaining walls, and such other items for which the Engineer demands the submission of the method of working. The Contractor shall provide information regarding the details of the method of working and equipment he proposes to employ and satisfy the Engineer about the adequacy and safety of the same. The sole responsibility for the safety and adequacy of the methods adopted by the Contractor will, however, rest on the Contractor, irrespective of any approval given by the Engineer.

103 INSURANCE

The Contractor shall provide and maintain the insurance cover in accordance with Clause 14 of the General Conditions of Contract from an approved insurance company from the start date to the end of the Defects Liability Period.

Measurement and Payment

No separate payment will be made for insurance. All costs involved in connection with the work insurance herein shall be considered included with other related items of the work in the Bill of Quantities.

104 SUBMITALS

1 General Requirements

The Contractor shall maintain an approved system of recording and tracking submissions indicating dates, status (i.e. approved, not approved, approved subject to conditions), quantities, and other details as required.

Copies of all approved submissions will be retained securely and properly filed on site, available for reference by the Engineer at any time.

2 Contractor's Monthly Progress Report

The Contractor shall report monthly progress report to the Engineer submitted in triplicate and showing actual work done superimposed upon copies of the program. He shall furnish an explanation of any deviation from the Program stating his proposals for improving progress should this be lacking in any respect and he shall furnish the Engineer with his amended critical path analysis in triplicate. The Contractor shall comply with the reporting requirements on implementation of Environmental Management Plan in the monthly report following the guidelines provided by the Engineer.

The contractor shall submit **monthly Laboratory/Field test** report including cumulative number of test done in the prescribed format. If required, the Engineer shall ask the contractor to submit quarterly Fund Projection Statement.

3 Samples

The Engineer may at his discretion request or take samples of any material or product intended for use in the Works. Where samples are requested in the Specifications they shall be submitted in the number requested or as directed by the Engineer.

Samples shall be of the type and size specified and fully representative of the materials proposed to be used. Samples shall be indelibly and clearly marked with the date of submission, material reference and any other data required to determine the source and kind of sample. One or more samples of each kind submitted will either be returned marked "ACCEPTED" and signed by a representative of the Engineer or the Contractor will be requested to provide new samples and be notified of deficiencies present in the submitted samples.

One or more "accepted" samples will be retained by the Engineer for comparison with materials and workmanship supplied and will form the standard of acceptance. One or more

“accepted” samples shall be retained at the Contractor’s site office and be available for reference on request.

The Engineer may reject any materials and goods which in his opinion are inferior to the samples thereof previously approved and the Contractor shall promptly remove such materials and goods from the Site.

4 Copies of Orders

The Contractor shall provide the Engineer with one copy of all orders for the supply of materials and goods required in connection with the Works as the Engineer may require.

5 Site Trials

Site trials of pavement and other similar works as specified shall be prepared by the Contractor for review and acceptance of the Engineer. They shall be in a location agreed with the Engineer, and if so specified may be incorporated into the work in a clearly identified position upon approval of the Engineer. The Contractor shall carry out such changes or carry out field trials as required obtaining the Engineer’s approval. Approved field trials shall form the standard of acceptance of subsequent materials and workmanship.

6 Construction Drawings

- a) The Contractor shall prepare and submit construction drawings for details of construction work, temporary or permanent works, if required under the contract.
- b) The construction drawings shall show at a suitable scale all the particulars of the work including dimension, materials, finishes, lines, levels, tolerances and other details to show compliance with the specification, the suitability of item for its compliance.
- c) The Engineer and his representatives will review the drawings only for their general compliance with the intent of the drawings and specifications. Responsibility for accuracy of dimensions, technical design, performance and suitability for intended purpose of the items shall remain with the Contractor.
- d) Three (3) copies of each construction drawing shall be submitted in sufficient time to allow for review, possible revisions and resubmission for approval prior to ordering materials, coordinating all affected and contingent work without delay to the schedule of construction.
- e) Two copies of all construction drawings will be retained by the Engineer. The remaining copies will be returned to the Contractor signed by a representative of the Engineer and marked “REVIEWED” with either:
 - a request for resubmission and notes as to deficiencies;
 - a note indicating the drawing has been reviewed but is subject to conditions noted or listed, and does not require resubmission; or
 - a note indicating the drawing has been reviewed and is considered to meet the intent of the design and does not require resubmission.
- f) The drawings shall be submitted at least two weeks before the commencement of construction of work for which these drawings are intended.

- g) Construction should not commence until the drawings have been reviewed and are returned under the Conditions of Contract except where instructed by the Engineer.
- h) The materials or products should not be ordered until drawings have been reviewed and are returned under Conditions of Contract except when instructed by the Engineer.

7 As Built Drawings

As built drawings shall be submitted by the contractor within 45 days of the completion of the contract. It is advisable that the Contractor prepares the as-built drawings as the work is completed at the site to facilitate checking and verification. The following requirements will apply:

- (a) The drawings shall be prepared in AUTOCAD and submit both soft and hard copies.
- (b) The drawings shall include all available information on existing conditions as well as new construction.
- (c) Site drawings shall include all the items as in the original drawings.
- (d) The drawings shall include the road plan and profiles; updated road inventory plan showing details of structures, road cross-sections at 20 meters intervals with finished levels, walls, drains, shoulders and other structures; details of slope stabilization, drainage, road retention works, road safety measures, etc.
- (e) Drawings shall be at a scale suitable for easy reference and as required to clearly depict all required information as directed by the Engineer.
- (f) The Contractor shall conduct such on-site checks as required to ensure the accuracy of the as-built drawings.
- (g) One original and four copies of drawings shall be submitted in bound sets sub-divided by discipline. Copyright of all materials submitted will remain with the Employer without further compensation or charge.

Measurement and Payment

No separate measurement and payment shall be made for above items. All costs in connection with the work specified herein shall be considered included with other related items of the work in the Bill of Quantities.

105 ACCOMMODATION 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 restoration of the area into its original condition. The Contractor shall take necessary safety procedures regarding traffic diversion or temporary road closures that are needed in execution of the works in accordance with the Specific Provisions of the Particular

Conditions of Contract (PCC). The Contractor shall take precaution regarding safety at road works. The Contractor shall strictly adhere to the prevailing DoR standards, guidelines or as instructed by the Engineer.

(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. For this the Contractor shall submit the time and period of the closure to the Engineer at least 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 thorough traffic, traffic diversions, as may be required, from such portions shall be constructed.

(b) Survey Control Points

Diversions shall be constructed so as not to damage or displace survey control points. In exceptional cases where this is not possible, arrangements shall be made to have survey control points suitably referenced before they are displaced.

(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 provided 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 5 m. Where diversions consist of two separate one-way lanes the minimum usable width of each lane shall not be less than 3 m.

(g) Temporary Drainage Works

All necessary temporary drainage works required for proper surface run-off, such as side drains, catch 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 obtained from side cut or from the immediate vicinity within the road reserve. If sufficient material cannot be obtained in this manner, material shall be transported 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 600 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 or in order to facilitate the proper grading 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 into 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 in half width, allowing traffic to use that half of the road not under construction 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 supply 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 construction, improvement and/or diversions. Barricades, traffic signs and warning boards shall be provided as per the requirements of 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 enough to resist traffic vibration, and be painted as per the instruction of the Engineer. 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 provided.

In some locations steel drums may also be placed. These drums shall be white-washed, blasted with sand and provided with retro-reflective tape strips, red on the left hand side facing oncoming traffic and white on the right hand side as appropriate. The minimum size of these tapes shall be 0.01sq.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.

Measurement and Payment

No measurement and/or payment shall be made for works required under Clause 105 of the Technical Specifications. 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.

106 MAINTENANCE OF SERVICES

If any government, publicly and privately owned service for drinking water, electricity, drainage, irrigation channels, sewers, telecommunication cables/lines and other services and structures, 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.

Drawings and scheduling the affected services like water pipes, sewers, cables, etc. owned by various authorities including government and public undertakings and local authorities shall be verified by the Contractor for the accuracy of the information prior to the commencement of any work.

The Contractor must also allow for any effect of these services and alternations 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.

No clearance or alterations to the utility shall be carried out unless ordered by the Engineer.

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.

The Contractor may be required to carry out the permanent removal or shifting or diversion of certain services/utilities on specific orders 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.

Measurement and Payment

No separate measurement and payment shall be made for the work of temporarily supporting; maintaining and protecting the government, publicly and privately owned services. 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.

107 SURVEY AND SETTING OUT

During the period of Commencement of works the Contractor shall resurvey the Base Lines, Traverse Points, 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.

The Contractor shall check, replace and supplement as necessary the station points, location of batter pegs(only if required) and agree any revised or additional station details with the Engineer.

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

Where a survey 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.

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 the Engineer and recorded.

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 25 m interval or as instructed by the Engineer, with marker pegs or/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.

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.

Accurate control of lines and levels shall be provided by the Contractor at all stages of the construction. In respect of road, control shall be at least 10 m interval or such 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 subgrade, sub base and base, the Contractor shall re-establish center line pegs at sufficiently close intervals to determine the edges of base and surfacing accurately.

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 manpower like assistants, prism men, labours to work under the direction of the Engineer as required.
- (b) provision of all necessary logistical support like hand tools, pegs and materials.
- (c) provision of survey equipment (total station, distomat) as required by the Engineer for survey works.

Measurement and Payment

No separate measurement and/or payment shall be made for the work required under Clause 107 of the Technical Specifications. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities.

108 ACCESS TO ABUTTING PROPERTIES

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

Measurement and Payment

No separate measurement and/or payment shall be made for the work required under Clause 108 of the Technical Specifications. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities.

109 MAINTENANCE OF ROAD

Maintenance of Existing Road

The Contractor shall be responsible for undertaking all routine maintenance of the existing road and all bridges on it under the contract from the day the road is officially handed-over to the Contractor until the issue of work completion certificate by the Engineer. The existing road and bridges on the road shall refer to the length of road and bridges within the contract package. The Contractor shall also carry out routine maintenance of all completed works from the time of their substantial completion until the work completion certificate is issued.

The Contractor shall also maintain roads that the Contractor 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 clearance of debris/ landslides of any volume; cleaning road signs and checking and undertaking the repair of guardrails/crash barriers and other road safety structures; cleaning including removal of obstructions of bridge decks and bridge deck of

drainage elements; cleaning and checking of expansion joints and bearings; cleaning bearing shelves and weep holes; removing accumulated debris and vegetation around and between 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.

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. The location and scope of the maintenance work shall be as directed by the Engineer.

The Contractor shall carry out reinstatement of works (pavement, pavement surface, shoulder or any other works) washed out or damaged due to poor routine maintenance of drains, drainage channels, culverts, shoulders; lacking clearance of obstructions such as landslides.

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 payment due to the Contractor.

Measurement and Payment

No separate measurement and payment shall be made for the works. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities.

No extra payment shall be made to the Contractor in case of reinstatement of works, washed out or damaged due to poor routine maintenance.

Maintenance of New Road Section

The Contractor shall be responsible for undertaking all routine maintenance of the completed works of new road construction including bridges till completion and handing/taking over of the project.

The Contractor shall also maintain roads that the Contractor 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 protection of plants and vegetation; cleaning of culverts, road side drainage (including reshaping/restoring in case of unlined drains) and drainage channels; and clearing any other obstructions including minor landslide and maintaining all completed road features to allow free flow of traffic. The material removed from the cleaning and clearing as above shall be disposed off at safe places as directed by the Engineer.

The Contractor shall carry out reinstatement of works (pavement, pavement surface, shoulder or any other works) washed out or damaged due to poor routine maintenance of drains, drainage channels, culverts, shoulders; lacking clearance of obstructions such as landslides etc other than those occurred due to earthquake.

The routine maintenance of newly constructed bridges shall include, cleaning including removal of obstructions of bridge decks and bridge deck of drainage elements, cleaning and checking of expansion joints and bearings, cleaning bearing shelves and weep holes, removing

accumulated debris and vegetation around and between piers and abutments, repairing parapets, and protection of adjoining works.

The Contractor shall perform the maintenance works as often as required to keep the carriageway, pavement, shoulders, and adjoining structures in proper working order to the satisfaction of the Engineer. The Contractor shall mobilize labour, equipment and materials to carry out the routine maintenance of the road. The location and scope of the maintenance work shall be 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.

Measurement and Payment

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

No extra payment shall be made to the Contractor in case of reinstatement of works, washed out or damaged due to poor routine maintenance of drains, drainage channels, culverts, shoulders; lacking clearance of obstructions such as landslides etc.

All damages resulting from poor quality of works, materials or workmanship shall be the responsibility of the contractor under defect liability period.

110 NOTICE BOARD

The Contractor shall erect and maintain notice boards (2m×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 contract period.

Measurement and Payment

No separate measurement and payment shall be made for the works. All costs in connection with the work specified herein shall be considered included in the related items of the work specified in the Bill of Quantities.

111 ENVIRONMENT 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 execution of the contract. He shall abide by all prevailing laws, rules and regulations governing environmental protection. In particular, the Contractor shall fully comply with the

Environmental Codes of Practice for Highways and Roads. The Contractor shall follow the requirements specified in the Environmental Management Plan for the environmental protection and management of the works under the contract. The Contractor shall be responsible for implementation of Environmental Management Plan (EMP) and compliance. As part of this, the Contractor shall follow the guidelines and submit the required information on monthly basis for monitoring of the EMP implementation by the Engineer. The Contractor at all time shall ensure that requirements of EMP are fulfilled.

The Contractor shall prohibit his/her employees from unauthorized handling/use of explosives, poaching wildlife, fishing and cutting trees. Where possible the workers must be provided with kerosene for cooking. Where it is not possible to get kerosene firewood must be provided by purchasing it through the local firewood contractor. Where there is no local firewood contractor, proper forestry permits must be obtained for collection of firewood. The Contractor shall be responsible for the action of his/her employees.

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

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

Various works defined under this item are related to provision and maintenance of camps for workmen and employees, Contractor's site offices, stores, equipment yards and workshops. These camps must be adequate, rain-proof, spacious, airy and hygienic with proper lighting 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 temporary 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. Camps must be located in stable areas where there are no possibilities of landslides or erosion. To prevent disturbance to nearby communities the labor camps must be located at least 500 m away from the nearest settlement.

Prior approval in writing must be obtained from the Engineer for proper establishment and maintenance of such camps. Failure to compliance with the Engineer's instruction in respect of overall standard will lead to reduction or withholding of any payment to the Contractor.

The Contractor shall ensure that proper drinking water, waste disposal and toilet facilities are provided to the camps. 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 supply of potable water within a week after the supply is commenced.

Provision of toilets for labour and employees shall be made to avoid public nuisance as well as pollution of water courses and air. Toilets shall not be located near streams or rivers. The Contractor shall construct suitable septic tanks and/or soak pits. Sufficient water must be provided and maintained in the toilets. Proper methods of sanitation and hygiene should be employed during the whole project duration. The contractor shall provide waste disposal facilities such as dustbins and waste disposal pits.

A first aid kit along with proper medical supplies must be made available in the camps for treating injuries or common health problems. Services shall also include on-the-way service and other arrangements required for taking them to the nearest hospital in case of emergency.

If imported laborers are required for construction, proper medical tests of the laborers shall be carried out to prevent the spread of diseases such as STD and HIV/AIDS amongst the communities near the construction sites. Arrangement should be made for the services of at least one part-time experienced health worker/health assistant with a minimum of once a week full time site visit. 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.

All workers shall be provided with adequate safety gears such as gumboots, gloves, face masks, ear plugs, helmets, safety jackets and safety belts to prevent injuries and health hazards.

During shifting of the camp all trash and unwanted material must be burnt or disposed off properly. Pit latrines must be adequately covered. Areas without any vegetation must be re-vegetated by carrying out appropriate bioengineering works.

(2) Site Clearance and Removal of Top Soil

Loss of trees and vegetative cover is a permanent impact that cannot be avoided. However, the Contractor shall take all measures to minimize removal of vegetation and remove only what is necessary. During clearing activities the Contractor shall make efforts not to disturb or destroy the vegetation outside the construction corridor. Proper clearing and grubbing procedures shall be followed in accordance with the Technical Specifications. The contractor shall store top soil of the cleared area and reused for carrying out bioengineering activities, as appropriate.

(3) Borrow/Quarry Sites

The contractor shall use approved borrow/quarry sites in the construction works. The Contractor shall abide by the rules and regulations of the governing bodies while operating, using river sand and rock quarries for the construction materials. All new rock quarry sites must be located in stable areas that are away from rivers, streams, settlements, drinking water intakes, cultivable lands and drainage systems.

The Contractor shall obtain the prior approval of the concerned authorities and permission of the Engineer before opening any borrow pits or quarries. Such borrow pits and quarries may be prohibited or restricted in dimensions and depth by the Engineer where they might:

- (i) affect the stability or safety of the works or adjacent property;
- (ii) interfere with natural or artificial drainage or irrigation;
- (iii) be environmentally unsuitable.

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

After completion of quarry operations the contractor shall restore the site properly. Where necessary the quarry site shall be restored immediately after completion of construction works. Restoration will include spreading of top soil and carrying out bioengineering works as per the instruction of the Engineer.

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 susceptible 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.

The cutting of trees shall be avoided or if necessary shall be carried out only after obtaining approval of the Department of Forests & Park Services. 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 Technical Specifications shall be made good immediately by the Contractor.

At least 14 days before the Contractor intends to commence opening up any approved borrow pit or quarry, the Contractor shall submit to the Engineer the 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 re-vegetation, including reinstatement of any access track.

Operation 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.

(4) 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 top soil of the tipping sites must be stored and reused for restoring the tipping site and carrying out bioengineering works. Provisions shall be made to facilitate proper drainage around the site.

(5) Crushing Plants

Crushing plants shall be located away from communities and water sources. Suitable dust control device shall be fitted to the crusher to control emission of dust from the plant. The plants shall be operated only during the day time to minimize disturbance to nearby communities and wildlife. Water shall be sprinkled on the crushing plant and surrounding areas to minimize dust. At the same time appropriate drainage measures shall be constructed to drain out excess water from the site in order to keep the area dry.

(6) Hot Mix Plants and Batching Plants

Hot-mix plants and 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 from the plants. No bituminous material shall be discharged into drains. Nearby trees, vegetation and property shall be protected during spraying of bitumen.

(7) Use of Bitumen including Heating and Storage of Bitumen

Heating of the bitumen will be necessary for use in pavement works. The bitumen will be heated using firewood or kerosene. Where it is necessary to heat the bitumen using firewood, the Contractor shall obtain firewood through local firewood contractor. In locations where there is no local firewood contractor the Contractor shall obtain forestry permits from the local territorial Forestry authorities for collecting firewood from the nearby forests. During application of bitumen improper storage of the bitumen barrels and bleeding of the bitumen shall be avoided to prevent scarring and loss of aesthetic of the landscape.

(8) 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 blasting methods shall be applied in construction works as per the Technical Specifications.

(9) Operation of Vehicles, Machinery and Equipment

The contractor shall regularly maintain all vehicles, machinery and equipment in order to minimize exhaust pollution. Oil and lubricants must be stored properly to prevent any spills and leakage and pollution of the surrounding soil as well as water bodies.

(10) Reinstatement of Environment

The Contractor shall arrange and execute works as well as related activities in such a way that environmental conditions are reinstated. The Contractor shall be required to carry out filling, 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 up to the end of Defects Liability Period.

Measurement and Payment

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

112 PHOTOGRAPHS

The Contractor shall undertake, maintain and provide photographic records of the existing condition and work progress. A complete photographic record of existing site conditions shall

be undertaken by the Contractor before commencing any work on site. The record shall include existing pavement, drainage, structures and site areas affected by the work in sufficient detail to clearly portray all existing conditions of structures, finished surfaces. No work shall be undertaken prior to receiving approval at any work site. The Contractor shall supply photographs, of such portions of the works in progress and completed, as may be directed by the Engineer. The negatives and prints shall not be retouched. 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

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.

Measurement and Payment

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

113 CONSTRUCTION EQUIPMENT

In addition to the conditions of the contract, the following conditions regarding use of equipment in the Works shall be complied by the Contractor:

- a) The Contractor shall be required to give a trial run of the equipment for establishing their capability to achieve the laid down Specifications and tolerances to the satisfaction of the Engineer before commencement of the work;
- b) All equipment provided shall be of proven efficiency and shall be operated and maintained at all times in a manner acceptable to the Engineer;
- c) All the plant/equipment to be deployed on the works shall be approved by the Engineer for ensuring their fitness efficiency before commencement of work;
- d) Any equipment not meeting the approval of the Engineer shall be removed from the site;
- e) No equipment will be removed from site without permission of the Engineer; and
- f) The Contractor shall promptly make available the equipment at site for quality control of works as directed by the Engineer.

No extra payment shall be made to the Contractor for fulfilling the above conditions regarding the use of equipment in the Works.

114 SITE INFORMATION

The information about the scope of work and site conditions in the Bidding Documents is given in good faith for guidance only but the Contractor shall satisfy himself regarding all aspects of site conditions.

The location of the works and the general site particulars are as generally shown on the Site plan/index plan enclosed with the Bidding Documents.

Whereas the Right-of-Way to the bridge sites/road works shall be provided to the Contractor by the Employer, the Contractor shall have to make his own arrangement for the land required by him for site offices, labour camps, stores, etc.

It is assumed that the Contractor has fully inspected the site, location of quarries; borrow areas etc., before quoting his rates for the work to assess the availability of construction materials in required quantity and quality.

115 NOTES ABOUT MEASUREMENT AND PAYMENT

(1) GENERAL RULES FOR THE MEASUREMENT OF WORKS FOR PAYMENT

1.1 General

All measurements shall be made in the metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant sections read in conjunction with the General Conditions of Contract.

All measurements and computations, unless otherwise indicated, shall be carried out nearest to the following limits.

I	length and breadth	: 10 mm
Ii	height, depth or thickness of earthwork, sub-grade, bases, surfacing and structural members	: 5 mm
Iii	Areas	: 0.01 sq.m
Iv	cubic contents	: 0.01cu.m

In recording dimensions of work, the sequence of length, width and height or depth or thickness shall be followed.

1.3 Measurement of Pavement Thickness for Payment on Volume Basis

The finished thickness of sub-base and base will be measured in volumetric basis. DBM and AC shall be measured in square meter.

(2) SCOPE OF RATES FOR DIFFERENT ITEMS OF WORK

2.1 For item rate contracts, the contract unit rates for different items of works shall be paid in full for completing the work to the requirements of the Specifications including full compensation for all the operations detailed in the relevant sections for these specifications under "Rates". In the absence of any directions to the contrary, the rates are to be considered as the full inclusive rate for finished works covering all labour, materials, wastage, transportation, temporary work, plant, equipment, overhead charges and profit as well as the general liabilities, obligations, insurance and risks arising out of General Conditions of Contract.

2.2 The item rates quoted by the contractor shall, unless otherwise specified, also include compliance with the following:

- (i) General works such as survey and setting out, clearance of site before setting out and clearance of works after completion;
- (ii) A detailed Program for the construction and completion of the works (using CPM/PERT techniques or equivalent) giving, 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/equipment and their installation and testing, and for all activities of the Employer that are likely to affect the progress of work, etc., including updating of all such activities on the basis of the decisions taken at the periodic site review meetings or as directed by the Engineer as per Clause 102 of the Technical Specifications.
- (iii) Samples of various materials proposed to be used on the Work for conducting tests thereon as required as per the provisions of the Contract;
- (iv) Design of mixes as per the relevant Clauses of the Specifications giving proportions of ingredients, sources of aggregates and binder along with accompanying trial mixes as per the relevant clauses of the Technical Specifications to be submitted to the Engineer for his approval before use on the Works.
- (v) Detailed design calculation and drawings for all Temporary Works (such as formwork, staging, centring; specialised constructional handling and launching equipment and the like);
- (vi) Detailed drawings for templates, support and end anchorage, bar bending and cutting schedules for reinforcement, material lists for fabrication of structural steel, etc.
- (vii) Mill test reports for all mild and high tensile steel and cast steel as per the relevant provisions of the Specifications;
- (viii) Testing of various finished items and materials including bitumen, cement, concrete, bearings as required under these Specifications and furnishing test reports/certificates;
- (ix) Inspection Reports in respect of form work, staging, reinforcement, and other items of work as per the relevant Specifications;
- (x) Any other data which may be required as per these Specifications or the conditions of Contract or any other annexes/schedules forming part of the contract;
- (xi) Any other items of works which is not specifically provided in the Bill of Quantities but which is necessary for complying with the provisions of the Contract;
- (xii) All temporary works as per (v) above;
- (xiii) Cost of in-built provisions for Quality Assurance;
- (xiv) Cost of safeguarding/protection of the environment;
- (xv) Cost of monthly progress reports, construction and as-built drawings and other submittals;
- (xvi) Cost of accommodation of traffic;
- (xvii) Cost of all taxes, duties and royalties;
- (xviii) Cost of site commissioning
- (xix) Cost of all operations like storing, erection, moving into final position, etc. necessary to complete and protect the work till handing over to the Employer; and

(xx) All incidental costs

2.3 Portions of road works beyond the limits of the contract and/or any other work might be constructed by the Employer through other contractors. Accordingly, other contractors employed by the Employer may be working in the vicinity of the Works being executed by the Contractor. The Contractor shall liaise with such contractors and carry out activities for the completion of work accordingly and no claim or compensation due to any reason whatsoever will be entertained on this account. The Employer will be indemnified by the Contractor for any claims from other agencies on this account.

117 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 substantial performance, the Contractor shall comply with the standards and codes specified in the contract documents.

118 UNITS OF MEASUREMENT

Units of Measurement

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

hr	hour
μ	micron = $m \times 10^{-6}$
mm	millimetre
m	metre
km	kilometre
sq. mm or mm^2	square millimetre
sq. cm or cm^2	Square centimetre
sq.m or m^2	square metre
sq. km or km^2	square kilometre
ha	hectare
cu. m. or m^3	cubic metre
lit or l	litre
rad	radian
°C	degrees Celsius
kg	kilogram
g	gram = $kg \times 10^{-3}$

mg	milligram = kg x 10 ⁻⁶
mg/l	milligram per litre
t	tonne = kg x 10 ³
kg/ m ³	kilogram per cubic metre
t/ m ³	tonne per cubic metre
N	newton
N/m ²	newton per square metre
Max	Maximum
Min	Minimum

Laboratories

Field laboratories

Field laboratories shall be established by the contractors at appropriate locations.

Measurement and Payment

Payment shall be made at the contract unit rates under the general item. The contractor shall built in the costs for payments to the support staff in the relevant items of BOQ.

(i) SECTION 200 - MATERIALS AND TESTING OF MATERIALS

- 201 SCOPE
- 202 QUALITY OF MATERIALS
- 203 SOURCES OF MATERIALS
- 204 INSPECTION AND ACCEPTANCE OF MATERIALS
- 205 MATERIALS AND MANUFACTURED ARTICLES
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- 212 CEMENT
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- 220 HIGH DENSITY POLYTHENE PIPES

- 221 GEOTEXTILES
- 222 TIMBER FOR STRUCTURAL WORKS
- 223 PAINT FOR ROAD MARKING
- 224 MANHOLE COVERS AND FRAMES
- 225 PRECAST CONCRETE CHANNELS
- 226 CAST IRON DRAINAGE GRATINGS
- 227 GABION
- 228 MEASUREMENT AND PAYMENT

SECTION 200 – CONSTRUCTION MATERIALS AND TESTING

201 SCOPE

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

202 QUALITY OF MATERIALS

The materials supplied and used in the works shall comply with the requirements of the Technical 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 skilfully to ensure completed works to comply with the contract.

203 SOURCES OF MATERIALS

The use of any one type 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 Codes of Practice, Highways and Roads" and "Blasting Manual" and comply with other pertinent environmental specifications including those detailed in Section

100 and other Sections. Prior approval of the material sources shall be required from concerned authorities as per the prevailing rules and regulations of Royal Government of Bhutan.

204 INSPECTION AND ACCEPTANCE OF MATERIALS

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. The Contractor/Engineers representative shall strictly follow the system of joint sampling and testing for material/ works as per format provided.

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 the Specifications.

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. The contractor shall strictly follow System of Request for Inspection (RFI) as per format provided.

205 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 proposes 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.

206 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. The Engineer/Engineers representative shall strictly follow the system of Non-conformance Report (NCR) in case of Non-conformance of materials/works as per formats provided.

207 TRADE NAMES AND ALTERNATIVES

For convenience in designation in the contract, certain articles or materials 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. The Contractor 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 article, 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.

208 FOREIGN MATERIALS

Materials which are manufactured, produced or fabricated outside Bhutan shall be delivered at a point in Bhutan 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 Bhutan and it shall be the Contractor's responsibility to deliver materials obtained from outside Bhutan to the point of delivery in Bhutan. The Contractor shall supply the facilities and make necessary arrangement 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 from the manufacturer, producer or fabricator of foreign material where required.

209 SIEVE SIZES

IS sieves 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.

In addition, sieves of other test standards shall be used as required in the Technical Specifications as directed by the Engineer.

210 SOILS AND GRAVELS

(1) Sampling and Samples

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

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

- (a) 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 19 mm 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 19 mm sieve. The material passing the 50 mm sieve and retained on the 19 mm sieve shall be weighed and replaced 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 2.1. The type of tests shall be as directed by the Engineer.

Table 2.1: Tests Procedures Applicable to Samples of Soils and Gravels

Tests	Test procedure	
Determination of:		
Moisture Content	IS 2720	Part 2 (Oven-drying method)
Liquid Limit	IS 2720	Part 5 (Cone Penetrometer or by Casagrande Apparatus)
Plastic Limit	IS 2720	Part 5
Plasticity Index	IS 2720	Part 5
Linear Shrinkage	IS 2720	Part 20
Specific Gravity of Particles	IS 2720	Part 3
Particle Size Distribution	IS 2720	Part 4
Organic Matter Content	IS 2720	Part 22
Total Sulphate Content	IS 2720	Part 27
Density-Moisture Content relationship (2.5 kg rammer)	IS 2720	Part 7
Density-Moisture Content relationship (4.5 kg rammer)	IS 2720	Part 8
California Bearing Ratio	IS 2720	Part 16
Sand Equivalent	IS 2720	Part 37 (Mechanical Shaker or Manual Shaker method)
Field Dry Density	IS 2720	Part 28/Part 29
Hydrometer analysis	IS 2720	Part 4

It is further specified that:

- (a) Wherever in the text of these Specifications the term "x % of the MDD (IS 2720 Part 27 or 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 2.1. Samples for the compaction tests shall be taken before compaction of the layers begin unless in the opinion of the Engineer the compaction 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 used in the determination of 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 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 90° 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.

211 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 2386 or according to sampling procedures specified for the Standard Methods of testing given in Table 2.2.

(2) Standard Methods of Testing

Tests on stone aggregate, sand and filler shall be performed in accordance with the standard procedures given in the Table 2.2. The type of tests shall be as directed by the Engineer.



Table 2.2: Tests Procedures Applicable to Stone, Aggregate and Fillers

Tests	Test Procedure	
Determination of:		
a) Particle Size Distribution (Gradation)	IS 2386	Part 1
b) Clay, Silt, Dust in Aggregates	IS 2386	Part 2
c) Flakiness Index	IS 2386	Part 1
d) Specific Gravity	IS 2386	Part 3
e) Moisture Content	IS 2386	Part 3
f) Bulk Density, Voids & Bulking	IS 2386	Part 3
g) Soluble Chloride Content	BS 812	Part 117
h) Mica Content	Manual mineralogical counting	
i) Water Absorption	IS 2386	Part 3
j) Crushing Ratio	Manual counting & weighing	
k) Los Angeles Abrasion	IS 2386	Part 4
l) AIV - ACV	IS 2386	Part 4
m) Polished Stone Value	IS 2386	Part 4
n) Sodium Sulphate Soundness	IS 2386	Part 5
o) Alkali Aggregate Reactivity Test	IS 2386	Part 7
p) Bitumen Stripping Test	IS 6241	
q) Deleterious Substances	IS 2386	Part 2
r) Sand Equivalent	IS 2720	Part 37
s) Crushing Strength of stone	IS 2386	Part 4

212 CEMENT

Ordinary Portland Cement (OPC) shall be sampled according to IS 3535 and tested according to IS 4031. The requirements on their physical characteristics shall be as given in Table 2.3.

Table 2.3: Requirements on the Physical Characteristics of Cement

S.N.	Physical characteristics	OPC	Test Procedure
i)	Fineness, m ² /kg: (by Blaine's Air Permeability method)	225	IS-4031 Part 2
ii)	Setting Time :		
	(a) Minimum Initial Setting Time (minutes)	45	IS 4031 Part 5
	(b) Maximum Final Setting Time (minutes)	600	
iii)	Soundness by Lechatelier method, mm, maximum	10	IS 4031 Part 3
iv)	Compressive Strength :		
	Minimum Average Compressive Strength of three mortar cube(N/mm ²)		

	(a) 3 days	16	IS 4031 Part 6
	(b) 7 days	22	
	(c) 28 days	33	

213 CONCRETE

Sampling and testing on concrete shall be carried out in accordance with the standard methods given in the Table 2.4. The type of tests shall be as specified by the Engineer.

Table 2.4: Test Procedures Applicable to Concrete

Tests	Test Procedures
Determination of :	
(i) Compressive strength of concrete cubes	BS 1881-116
(ii) Water absorption	BS 1881-122
(iii) Mixing and sampling fresh concrete in laboratory	BS 1881-125 BS 1881-111
(iv) Normal curing of test specimens (20° C method)	BS 1881-108
(v) Making test cubes from fresh concrete	

The test specimens shall be cured at a temperature of $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Water to be used in concrete shall be tested as specified in BS 3148.

214 BITUMINOUS BINDERS

(1) Sampling and Samples

Sampling of straight-run and cut-back bitumen shall be carried out in accordance with ASTM D 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 AASHTO 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 2.5. The type of tests shall be as instructed by the Engineer.

Table 2.5: 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/D1754
v) Ductility	ASTM D 113
vi) Water Content	ASTM D1461/D95
vii) Solubility in Trichloroethylene	ASTM D 2042
viii) Specific gravity	ASTM D70
)	
ix) Penetration of residue from loss on heating	ASTM D5

(b) Cut Back Bitumen

Test on cut-back bitumen shall be carried out in accordance with the standard methods given in Table 2.6. The type of tests shall be as directed by the Engineer.

Table 2.6: Tests Procedure Applicable to Cutback Bitumen

Tests	Test Procedure
Determination of :	
i) Kinematic viscosity	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
Penetration	ASTM D 5
iii)	
Specific gravity by hydrometer method	ASTM D 3142
iv)	
v) Asphalt residue of 100 pen (SC)	ASTM D 243
vi) Water content	ASTM D 95
Distillation	ASTM D 402
vii)	
Penetration of residue from distillation	ASTM D 5
viii)	
)	
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 2.7. The type of tests shall be as directed by the Engineer.

Table 2.7: Tests Procedure Applicable to Bitumen Emulsion

Test	Test Procedures
Determination of :	
(i) Residue on 0.710 mm sieve	BS 434 Part I, Appendix C ₁
(ii) Residue on 0.150 mm sieve	" " " C ₂
(iii) Stability to mixing with coarse aggregate	" " " D ₁
(iv) Stability to mixing with cement	" " " D ₂
(v) Binder content	" " " E
(vi) Engler viscosity	" " " F ₁
(vii) Redwood II viscosity	" " " F ₂
(viii) Storage stability (short period)	" " " H ₁
(ix) Storage stability (long period)	" " " H ₂
(x) Particle charge	" " " J

(3) Requirements

(a) General

Before any bituminous binder is delivered to the site, the Contractor shall provide the Engineer with a certificate from 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 Bitumen

Straight run bitumen shall comply with all the requirements give in Table 2.8.

Table 2.8: Specification for Straight run Bitumen

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

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

215 BITUMINOUS/ASPHALT CONCRETE MIXTURES

(1) Sampling and Samples

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

(2) Standard Methods of Testing

Tests on bituminous mixtures shall be carried out in accordance with the standard methods given in Table 2.9.

Table 2.9: 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, IS 6241
vi) Degree of particle coating	ASTM D 2489
vii) Maximum specific gravity	ASTM D 2041
vii) Degree of pavement compaction	AASHTO T230
ix) Marshall stability	ASTM D1559

216 REINFORCING STEEL

All reinforcement for use in the Works shall be tested for compliance as specified in the TS in a Laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. In addition to the testing requirements described above, the Contractor shall carry out additional testing as instructed by the Engineer.

217 BRICKS

Bricks shall conform to the requirements of IS 1077.

218 MORTAR

Mortar shall comply with IS 2250–1981.

219 REINFORCED CONCRETE PIPES

Reinforced concrete pipes shall comply with the requirements of IS 458:1988.

220 HIGH DENSITY POLYTHENE PIPES

High density polythene pipes shall be as approved by the Engineer.

221 GEOTEXTILES

Geotextiles used for sub-surface drains shall be continuous fibre non –woven, needle punched; UV stratified such as “polyfelt TS 30 or equivalent”.

Geotextiles used for reinforcing walls shall be non-woven, needle punched; UV stratified such as “polyfelt TS 70 or equivalent”.

Unless otherwise shown on the Drawing or directed by the Engineer, the geotextiles shall meet the specifications in Table 2.10.

Table 2.10 Requirement of geotextiles

Property	Test standard	Unit	10KN geotextile	24KN geotextile
Tensile strength(Av)	ISO 10319	KN/m	9.5 min	24
CBR puncture strength	ISO 12236	N	1200	3000
Vertical water flow (100mm head)	ISO 11058	l/m ² /s	217	117
Rod Puncture resistance	ASTM D 4833	N	255	650
Apparent opening size (O95)	ASTM D 4751	mm	0.26	0.18
Permittivity	ASTM D 4491	l/s	3.0	1.70
Nominal mass	ISO 9864	g/m ²	125	325
Thickness 2Kpa	ISO 9863	mm	1.2	2.9
Weight of roll		kg	135/60	140

- (a) Geotextiles shall have a grab strength more than 475/420 N for 10 KN and 1500/1400 for 24 kn and grab elongation corresponding to this limit in accordance with ASTM D4632.
- (b) apparent opening size should be as shown on the Drawing or as mentioned under table 2.1.
- (c) allow vertical water to flow through it at right angles to its principal plane, at a rate of not less than 217 litres/sq.m./sec for 10KN geotextiles and 117 litres/sq.m./sec for 24 KN geotextiles under a constant head of 100 mm, determined in accordance with BS: 6906 (Part 3) or ASTM D4491, or ISO 11058, unless otherwise shown on the Drawing. The flow rate determined in the test shall be corrected to that applicable to a temperature of 15⁰C using data on variation in viscosity of water with temperature.
- (d) minimum dynamic drop cone puncture should be of 30 mm diameter when determined in accordance with ISO 13433.

Geotextiles used for drilled sub-surface drains shall also be as specified above and as per Section 1700.

222. TIMBER FOR STRUCTURAL WORKS

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

223. PAINT FOR ROAD MARKING

The paint for road marking shall be manufactured for road markings and suitable for use in the climatic conditions of Bhutan. Paint colors shall be as shown on the Drawings. The paints shall be to the approval of the Engineer.

224 MANHOLE COVERS AND FRAMES

Manhole covers and frames shall be of cast iron and shall comply with IS: 1726-1991. For manholes constructed in carriageway and shoulders, 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.

225 PRECAST CONCRETE CHANNELS

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

226 CAST IRON DRAINAGE GRATINGS

Cast iron gratings shall comply with the requirements of IS: 5961 – 1970.

227 GABION

All wire used in the fabrication of gabion boxess and wiring operations during construction shall comply with the requirements of IS 280. The wires shall be galvanised with heavy coating of zinc. The coating of zinc shall comply with IS 4826 (Heavy Coated Wire).

228 MEASUREMENT AND PAYMENT

Unless otherwise specified in the contract, no separate measurement and payment shall be made for sampling, samples and testing of materials, site 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 Section.

SECTION 300 - QUALITY CONTROL

- 301** SCOPE
- 302** RESPONSIBILITY OF CONTRACTOR FOR QUALITY OF WORKS
- 303** QUALITY CONTROL SYSTEM
- 304** QUALITY ASSURANCE PLAN
- 305** TESTING PROCEDURES AND SETS OF TESTS
- 306** LABORATORY TRIALS TO CONFIRM COMPLIANCE WITH SPECIFICATIONS
- 307** SITE TRIALS OR TRIAL SECTIONS
- 308** CONTROL TESTING DURING CONSTRUCTION
- 309** ACCEPTANCE TESTS FOR COMPLETED WORKS OR PARTS OF THE WORKS
- 310** RECAPITULATIVE SCHEDULE OF TESTS
- 311** LABORATORY

SECTION 300 - QUALITY CONTROL

301 SCOPE

This Section covers the Quality Control System and procedures, Quality Assurance Plan, program of tests, trials, and 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.

302 CONTRACTOR'S RESPONSIBILITY FOR QUALITY OF WORKS

All materials incorporated and all workmanship performed shall be strictly in conformity with the requirements of the Technical Specifications and the Contractor shall be fully responsible for the quality of the works.

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 quality control of the materials and for the quality control of workmanship in accordance with these Specifications. The list of laboratory equipment to be procured and laboratory facilities to be provided shall require approval 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 or part of works.

303 QUALITY CONTROL SYSTEM

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

(1) Sequence

- (a) Compliance testing for materials including laboratory trials,
- (b) Compliance testing for methods and equipment prior to the commencement of the work, including site trials or trial sections,
- (c) Control testing during construction,
- (d) Acceptance 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 Contract.

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 as per the provisions in the contract.

304 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 Program of the Works as per the Technical Specifications. A sample copy of the Quality Assurance Plan is provide.

The Quality Assurance Plan shall include the following:

(1) The Quality Control Schedule comprising of:

- (a) The recapitulative test schedule and testing program detailing the list of tests for compliance, laboratory trials, site trials and trial 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 Program.
- (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 organisation 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 102.
- (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 re-approval 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 program of the works as per the Conditions of Contract.

305 TESTING PROCEDURES AND SET 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 as specified in the respective Sections of these Specifications. The specified testing 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 the Specifications.

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.

306 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 Section 200. 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 307 to ensure that all specified requirements of the completed pavement courses can be achieved.

The Contractor shall submit the proposals for the site trials to the Engineer at least two weeks before he intends to use the mixed materials in the site trials in accordance with Clause 307.

(2) Concrete

Laboratory trials for concrete mixes as specified in TS shall be carried out by the Contractor to demonstrate that the composition of the mixes proposed for the concrete meets the requirements of the Technical 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 307.

307 SITE TRIALS OR TRIAL SECTIONS

(1) Earthworks and Pavement Materials

Site trials 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 compaction of 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 Program 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 compaction effort the Contractor is proposing. The data in respect of the following shall be recorded for each level of compaction 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 compaction effort. If all eight sets of results over the range of compaction 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 TS 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 Program 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 to 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 program, 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, stripping 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.

308 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. 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

Testing and quality control procedures for other works and equipments are detailed in the relevant Sections of the Technical Specifications.

309 ACCEPTANCE 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 using standard Request for Inspection sheet (RFI) 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 303 (1) (a), (b), (c) and the relevant Sections of the Technical Specifications.

The Engineer shall thereupon, without undue delay, inspect the Section for any visible defects including, heaving material (visible during compaction or on proof rolling) 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. The Engineer/Engineers representative, for this purpose, shall use the standard Non –Conformance Report form (NCR).

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 re-approval of the layer and the layer shall again be subject to proof rolling, 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 proof rolling, 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 the Technical Specifications.

310 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 the Technical Specifications. The frequency of tests to be conducted shall be as per Table 3.1 or as directed by the Engineer.

The following Table 3.1 recapitulates the testing schedule for the main types of works.

Table 3.1: Testing Schedule

PART OR COMPONENT OF THE WORKS	Section/ Clause No	TESTS	FREQUENCY
PRODUCTION OF NATURAL AND CRUSHED MATERIALS	400	<ul style="list-style-type: none"> Site Trails: Other tests on materials 	<ul style="list-style-type: none"> Before starting production According to the relevant component of the works
EARTHWORKS FILL MATERIAL COMPACTION	600	<ul style="list-style-type: none"> Material Identification, MDD, OMC, CBR MC Field Density 	<ul style="list-style-type: none"> 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 One set per 500m² of each layer with a minimum 3 test per Section
SUBGRADES MATERIALS (REPLACEMENT) COMPACTION	700 703 & 704	<ul style="list-style-type: none"> Material Identification, MC MDD, OMC, CBR Field Density 	<ul style="list-style-type: none"> For each new material and not less than once per 3000 m² of each layer Once per 500 m² of each layer or part of it
MECHANICAL STABILISATION IN-SITU MATERIAL STABILISER MIXED MATERIAL	705	<ul style="list-style-type: none"> Material Identification, MC MDD, OMC, CBR Grading, se (for sand) MDD,OMC,CBR,MC Field Density 	<ul style="list-style-type: none"> 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 per 400 m² of each layer or

COMPACTION			<p>part of it.</p> <ul style="list-style-type: none"> Once per 250 m² of each layer or part of it.
SUB BASE	900		
MATERIALS		<ul style="list-style-type: none"> Material Identification, MC, Gradation, Plasticity Index, MDD, OMC 	<ul style="list-style-type: none"> 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.
COMPACTION		<ul style="list-style-type: none"> Field Density and moisture content 	<ul style="list-style-type: none"> Once per 500 m² of each layer with a minimum of 2 tests per section.
WET MIX CRUSHED STONE BASE COURSE	1001		
MATERIALS		<ul style="list-style-type: none"> Material Identification, Gradation, Plasticity Index, FI LAA, AIV, Crushing Ratio, SSS, CBR MDD, OMC 	<ul style="list-style-type: none"> Once per 200 m³ or part of it and change in source with a minimum of 2 tests per section Once per 200 m³ or part of it and every change of source Once per 500 m³ or part of it and every change of source Once per 1000 m³ or part of it & every 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.
COMPACTION		<ul style="list-style-type: none"> Field Density and moisture content 	
GRAVEL WEARING COURSE	1003		
MATERIALS		<ul style="list-style-type: none"> Material Identification, Gradation, Plasticity Index, CBR, LAA, AIV MDD, OMC 	<ul style="list-style-type: none"> Once per 300 m³ or part of it and for each new source Once per 400 m³ or part of it and for each change in sources Once per 200 m² of each layer with a minimum of 3 tests per Section.
COMPACTION		<ul style="list-style-type: none"> Field Density and moisture content 	
BITUMINOUS SURFACE AND PAVEMENT	1200		

<p>COURSES</p> <p>PRIME COAT - TACK COAT</p> <p>MATERIALS</p> <p>CONSTRUCTION</p>	<p>1202</p>	<ul style="list-style-type: none"> • Quality of Binder • Binder temperature for application • Rate of spread of binder 	<ul style="list-style-type: none"> • Certificates from suppliers. • One set of tests for each 50,000 litres of supply or part of it • At regular close intervals • 2 tests per run
<p>SURFACE DRESSING</p> <p>MATERIALS</p> <p>CONSTRUCTION</p>	<p>1203</p>	<ul style="list-style-type: none"> • Material Identification, Gradation, FI • LAA, AIV, CR • SSS • Striping Value • Quality of Binders • Rate of application of Chippings • Binder temperature for application • Rate of application of Binder. 	<ul style="list-style-type: none"> • 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. • Certificates from suppliers. • One set of tests for each 50,000 litres or part of it of supply. • Two per day • At close intervals • Two per run
<p>DBM/ASPHALT CONCRETE</p> <p>MATERIALS</p>	<p>1205</p>	<ul style="list-style-type: none"> • Material Identification, Gradation, LAA, ACV, SSS, SE Flakiness Index Quality of Filler • Quality of Binders Penetration test • Mixture 	<ul style="list-style-type: none"> • Once per 100 m³ and change in source • Once per 500 m³ and change in source • Once per 100 m³ " " • Per 50 tonnes " " • Certificates from suppliers. • One set of tests for each

CONSTRUCTION		Grading and Bitumen Content Marshall stability, flow & voids • Control of Temperature	50,000 litres of supply or part of it • Daily • Each 100t of mix or part of it • Each 100t of mix or part of it • As required
STONE MASONRY WORK	1302	• Quality of cement and sand	• As required
MATERIALS			
MORTAR	1313	• Control tests Compressive strength of mortar	• Every 10m ³ of masonry of part of it
BRICK MASONRY WORK			
MATERIALS	1402	• Quality of Bricks • Quality of cement and sand	• As required
MORTAR	1412	• Control tests Compressive strength of mortar	• Every 10 m ³ of brick work or part of it.
GABIONS			
MATERIALS	1501	• Gabion wires : Tensile Strength, Mass, Uniformity and adhesion of Zinc coating • Water absorption of stones	• Sub-clause 1501 • Every 50 m ³ or part of it
CONCRETE MATERIALS	1600	• Cement : Acceptance Tests: Control Tests : Chemical composition Physical properties • Aggregates: Acceptance Tests : Control Tests : Grading Silt & clay content Organic Impurities Chloride content, sulphate content,	• 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 1603 (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

			Alkali reactivity Water, Admixtures Concrete <ul style="list-style-type: none"> • Lab. Trials • Site Trials • Control tests Compressive strength Reinforcement	required. <ul style="list-style-type: none"> • Sub-clause 1603 (7) and (8) • Sub-clause 1504 (3) • Sub-clause 1504 (4) • Early work: every 6 m³ of each class. When compliance is established: every 20 m³ or part of it. • Clause 1614
CROSS DRAINAGE WORKS	1700		Identification : Gradation, Plasticity Index, CBR , In-Situ Density (95% MDD)	As specified or required by the Engineer
MATERIALS FOR RE-FILLING THE TRENCHES				

311 LABORATORY

(1) Scope

This Clause covers the laboratories as required for testing of materials as part of quality control of the construction works executed under the contracts for the project. The following laboratory provision will be required to cover the quality control of construction materials/works in the project highway sections and feeder roads.

(a) Establishment of Field Laboratory

The Contractor working for each contract package, shall establish a field laboratory. The laboratory shall be manned by the Contractor's team with qualified Material Engineer and laboratory technicians. The space should be adequate to provide testing facilities for construction works. A laboratory space of minimum 175 sqm is required. As required the space shall be partitioned to provide rooms/space for testing, sample preparation, sample storage, office and toilet and to accommodate the Material Engineer and his support staff (technicians) of the Supervision consultant's team when required.

The Contractor shall give following consideration to the preparation of space for laboratory. The floor of the laboratory shall be smooth concrete of sufficient quality to withstand the expected use. All rooms shall be painted, provided with sufficient ceiling lights and power outlets. All doors shall have a lock with two keys, and all doors and windows shall be fitted with sun and mosquito screens as required. Piped water suitable for drinking use shall be supplied to the laboratory building, together with tank storage sufficient to provide supply for 24 hours. Sufficient power for lighting and other electrical appliances and apparatus shall be provided.

The laboratory shall be provided with a telephone line with STD connection and email/internet services as available. The Contractor shall build in this cost in his rates for this item.

(4) Laboratory Equipment

All equipment necessary for testing of materials and workmanship shall be deemed to form part of the permanent works unless otherwise provided 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 304 (1) (c).

Table 3.2: Schedule of Laboratory Equipment

SN	Item Description	No. of Items
1.	<u>Grain Size Analysis (coarse sieves)</u>	
	a) 450 mm dia G.I. Sieves for coarse aggregates	
	150mm	2 no.
	100 mm	2 no.
	75.0 mm	2 no.
	63.0 mm	2 no.
	50.0 mm	2 no.
	40.0 mm	2 no.
	37.5 mm	2 no.
	28.0 mm	2 no.
	25.0 mm	2 no.
	20.0 mm	2 no.
	19.0 mm	2 no.
	16.0 mm	2 no.
	14.0 mm	2 no.
	13.2 mm	2 no.
	12.5 mm	2 no.
	10.0 mm	2 no.
	9.5 mm	2 no.
	6.30 mm	2 no.
	5.00 mm	2 no.
	4.75 mm	2 no.
	b) G.I. Pan (450 mm dia)	As required
	c) G.I. Cover (450 mm dia)	
	d) Wire Sieve Brushes	

SN	Item Description	No. of Items
2	<p><u>Grain Size Analysis (fine aggregate)</u></p> <p>a) 200 mm dia Span Brass Wire Sieve for fine aggregate</p> <ul style="list-style-type: none"> 4.75 mm 2.36 mm 2.00 mm 1.18 mm 1.00 mm 0.60 mm 0.425 mm 0.300 mm 0.212 mm 0.150 mm 0.075 mm <p>b) Brass Pan (200 mm dia)</p> <p>c) Brass Cover (200 mm dia)</p> <p>d) Wire Sieve Brushes</p> <p>e) Sieve Shaker motorised, 220 V, 50 Hz, single phase supply</p>	<ul style="list-style-type: none"> 2 no. 2 no. 2 no. 2 no. 2 no. 2 no. 4 no. 2 no. 2 no. 4 no. 6 no. 2 no. 2 no. 6 no. 1 set
3.	<p><u>Specific Gravity and Bulk Density</u></p> <p>Pycnometer preferred with capillary opening 50 ml</p> <p>Pycnometer preferred with capillary opening 250 ml</p> <p>Pycnometer preferred with capillary opening 1000 ml</p> <p>Wire Basket (4 mm mesh size)</p> <p>Bucket for Immersing Aggregate</p> <p>Bulk Density Measures (20 ltr., 10 ltr)</p> <p>Tamping Rod (16 mm dia.)</p>	<ul style="list-style-type: none"> 2 no. 2 no. 2 no. 1 no. 2 no. 2 set 1 no.
4.	<p><u>Liquid Limit Device with Counter Number</u></p> <p>Grooving tool and Gauge</p> <p>Removing Counter Kit</p> <p>Spatula (Flexible with round tip, 80 mm long and 20 mm wide blade)</p> <p>Sample Container (steel) with cover</p> <p>Wash bottle</p> <p>Glass plate (Absorbent type) [300 mm x 450 mm]</p> <p>Plastic Limit Rod Compactor</p> <p>Porcelain Dish, 120 mm dia.</p>	<ul style="list-style-type: none"> 1 no. 1 no. 1 no. 2 no. 20 no. 2 no. 2 no. 2 no. 2 no.
5.	<p><u>Proctor Compaction Apparatus</u></p> <ul style="list-style-type: none"> - Compaction moulds 150 mm dia. - 4.5 kg. Rammer - Compaction moulds 100 mm dia. - 2.5 kg. Rammer - Gauging Trowel - Straight edge (steel) - Vernier Calliper, 0-200 mm x 0.05 mm (equivalent to 	<ul style="list-style-type: none"> 2 no. 3 no. 4 no. 2 no. 2 no. 4 no. 1 no. 6 no.

SN	Item Description	No. of Items
	Mitutoyo) - Sample trays (600 mm x 600 mm x 75 mm) - sample trays (450 mm x 270 mm x 45 mm) - sample trays (270 mm x 210 mm x 4500 mm) - sample tray (220 mm x 175 mm x 45 mm) - Sample extruder (Hydraulic) - Rubber Gloves as required	6 no 6no 6no 1no
6.	<u>California Bearing Ratio (CBR) Apparatus</u> - CBR Moulds - Spacer Disc - Swell Plate - Tripod Attachment - Dial Indicator - Surcharge Weight - Filter Paper, Boxes - Filter Screen - Mechanical Loading Press	9 no. 9 no. 9 no. 9 no. 10 no. 36 no. 3 no. 3 no. 1 no.
7.	<u>Field Density Test (Sand Cone Method)</u> - Sand Pouring Cylinder 150 mm dia. - Sand Pouring Cylinder 200 mm dia. - Calibrating Container 150 mm dia. - Calibrating Container 200 mm dia. - Metal Trays (400 mm x 400 mm x 50 mm) with central hole - Density Spoon (medium) - Metal dibber tools - Scoops - Brush (different sizes) - Chisel - 1 kg Hammer - Trowels - 1 kg Rubber Mallets - Covered Containers (moisture sampling) - Standard Density Sand 850 /600	4 set 4 set 1 no. 1 no. 4 no. 4 no. 4 no. 4 no. 6 no. 4 no. 4 no. 4 no. 4 no. 4 no. 14 no. 500 kg
8.	<u>Concrete Test and Slump Cone Apparatus</u> - Cube Moulds (150 mm) - Slump cone apparatus - Tamping rod (16 mm dia) - Steel ruler (calibrated)	24 no. 2 no. 2 no. 2 no.
9.	<u>Compression Testing Machine</u> <i>(only for those packages which have heavy concreting works)</i> - Testing machine set (electric and hand driven), 100 t	1 set

SN	Item Description	No. of Items
10.	<u>Flakiness Index</u> <ul style="list-style-type: none"> - Flakiness Sieves 10 mm - 5.0 mm - Flakiness Sieves 14 mm - 10 mm - Flakiness Sieves 20 mm - 14 mm - Flakiness Sieves 28 mm - 20 mm - Flakiness Sieves 37.5 mm - 28 mm - Flakiness Sieves 50 mm - 37.5 mm 	<ul style="list-style-type: none"> 2 no 2 no 2 no 2 no 1 no 1 no
11.	<u>Bitumen Penetration</u> <ul style="list-style-type: none"> - Standard Penetrometer - Standard needles - Transfer Dish + Transparent glass dishes - Standard Trays for Binder heating - Digital Thermometer with probe, 0° to 300° C - 	<ul style="list-style-type: none"> 1 set 4 no 12 no 2 no 2 no
12.	<u>Softening Point Test</u> <ul style="list-style-type: none"> - Complete test set with ring and ball arrangements including water bath - Glass plate (300 mm x 5 mm) - Thermometer, -2° to 400° C - Thermometer, 30° to 200° C 	<ul style="list-style-type: none"> 1 set 2 no 2 no 2 no
13.	<u>Specific Gravity and Water Absorption Test</u> <ul style="list-style-type: none"> - Gas Jar (75 mm dia x 300 mm high with glass cover) - Tamping Rod 	<ul style="list-style-type: none"> 1 set 1 no
14.	<u>Bulk Density of Aggregates</u> <ul style="list-style-type: none"> - Bulk density measure, 10 dm³ - Bulk density measure, 7 dm³ - Tamping bar - Tamping Rod - Straight edge - Balance 10 kg capacity 	<ul style="list-style-type: none"> 1 no 1 no 1 no 2 no 1 no 1 no
15.	<u>Compaction of Bituminous Mixtures and Marshall Test</u> <i>(only for packages which have DBM and AC)</i> <ul style="list-style-type: none"> - Compaction mould - Compaction mould body - Compaction pedestal - Compaction hammer (4.5 kg) - Sample extruder - Marshal Tester (Motorized Load frame 50 kN) - Breaking head stability mould - Dial Gauge (various capacity) - Water Bath with Thermostat 	<ul style="list-style-type: none"> 2 no 2 no 1 no 1 no 1 set 2 no 4 no 1 no 1 no

SN	Item Description	No. of Items
16.	<p><u>Binder Determination (Centrifuge Extractor Method) <i>(only for packages which have DBM and AC)</i></u></p> <ul style="list-style-type: none"> - Hand operated extractor, 1500 g capacity - Filter discs (100 per pack) - Bowl 	1 set As reqd 2 no
17.	<p><u>Balances: (as specified)</u></p> <ul style="list-style-type: none"> a) Buoyancy Balance, 10 kg capacity, 0.1 g accuracy for specific gravity determination b) Triple Beam Balance, 2610 g, 0.1 accuracy (equivalent to OHAUS) c) Triple Beam Balance with carrying case, 10 kg, 0.1 g accuracy (equivalent to OHAUS) d) Heavy Duty Solution Balance, 20 kg, 1 g accuracy (equivalent to OHAUS) 	1 no 2 no 2 no 1 no
18.	<p><u>Glassware: (as specified)</u></p> <ul style="list-style-type: none"> a) Flat bottom flasks 500 ml b) Volumetric Flask, 500 ml c) Graduated glass beakers (100 ml - 1000 ml) d) Measuring cylinder (100 ml - 1000 ml) e) Glass rod dia 10 mm x 400 mm long f) Reagent bottles (500 ml - 1000 ml) g) Spare corks for bottles 	6 no. 6 no 12 no 6 no 6 no 12 no 12 no

SN	Item Description	No. of Items
19.	<u>Miscellaneous Equipment: (as specified)</u>	
	- Laboratory oven(250°), 220 V, 50 Hz, Single Phase, Thermostatically controlled, 330 dmsu ³	2 no
	- Air circulated laboratory oven, 220 V, 50 Hz, single phase, 250 dm ³	1 no 1 set
	- Hydrometer set (consisting of 1 hydrometer and 6 hydrometer jars, 1000 ml)	2 no 2 no
	- Speedy moisture tester	2 no
	- Pocket type thermometer, 0-250°C	2 no
	- Metal thermometer, 0-25°C	2 no
	- Armoured Thermometer, 0-100°C x 1°C	4 no
	- Dial Thermometer, 0-250°C x 2°C	3 no
	- Stopwatch	20 no
	- Sample splitter, 25 mm, 19 mm, 12 mm size or as specified	24 no 24 no
	- Moisture can, 90 mm diameter 50 mm, deep	12 no
	- Mixing pan 400 mm x 100 mm x 765 mm,	36 no
	- Mixing pan 220 mm x 100 mm x 75 mm,	3 no
	- Mixing pan 450 mm x 450 mm x 75 mm	1 no
	- Tin sample boxes	3 no
	- Laboratory tongs	2 no
	- Wire gauges	2 no
	- Electric hot plates, 220/50 1000 watts	8 no
	- 10-20 litre buckets, stainless steel or equivalent	8 no
	- Aluminium pot 3 litre capacity	3 no
	- Kitchen knives, stainless steel	1 no
	- Kitchen spoons, stainless steel	2 no
	- 10 litre jerry cans	4 no
	- Yield bucket	4 no
	- Spades	2 no
	- Hammer 1KG,5KG	2 no
	- Chisel 300mm long	
	- Steel calibrated ruler	
	- Others as required	

(4) Ownership

Unless otherwise stated in the contract the ownership of all testing equipment and furniture under each field laboratory shall become the property of the concerned contractor upon completion of the project.

(5) Attendance

The Contractor shall keep the laboratory 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. Testing apparatus shall be maintained in serviceable condition and all measuring and control equipment will be checked and calibrated from time to time, as required by the Engineer, and immediately adjusted or replaced if it is found that correction is not possible. Any equipment, which become unserviceable during use shall be repaired or replaced by the Contractor at no extra cost to the Employer.

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

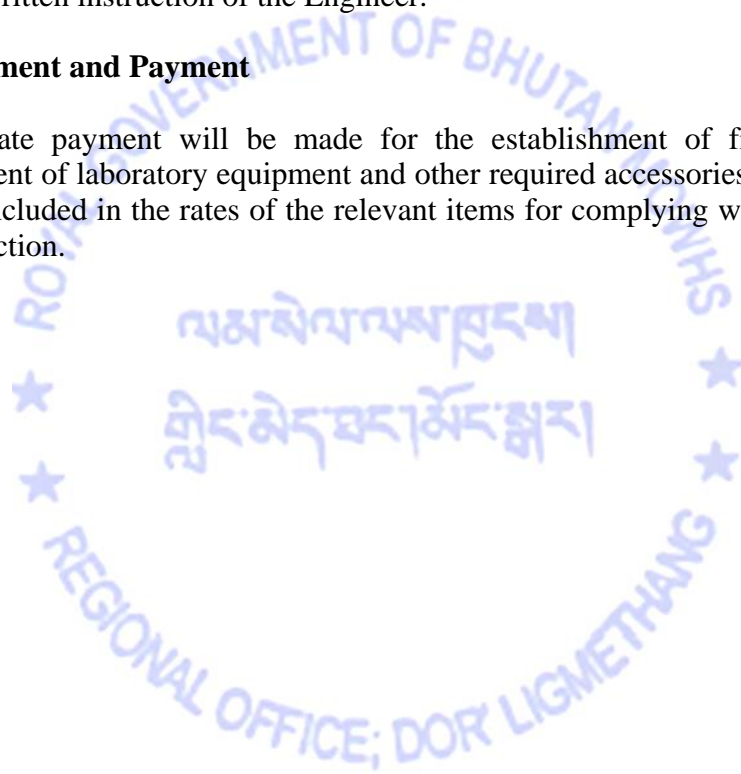
(6) Testing

Without relieving the Contractor of any of his responsibility for the testing of materials the Engineer may as and when he desires carry out any of the tests specified above using the facilities. The Engineer may order the Contractor to carry out additional laboratory tests in independent laboratory, as deemed necessary.

For all testing which cannot be carried out in the Laboratory at the Site, the Contractor shall be responsible for arranging for such testing to be carried out at an independent laboratory to be approved by the Engineer. The Contractor shall be responsible for all attendance on staff from these approved testing laboratories, including if necessary the provision of transport for personnel, equipment and test specimens. No testing by external laboratories shall be carried out without the written instruction of the Engineer.

(7) Measurement and Payment

No separate payment will be made for the establishment of field laboratory and arrangement of laboratory equipment and other required accessories. It shall be deemed to have included in the rates of the relevant items for complying with the requirements of this Section.



SECTION 400 - QUARRIES, BORROW PITS, STOCKPILE AND SPOIL AREAS

- 401 GENERAL
- 402 DEFINITIONS
- 403 IDENTIFY MATERIAL SOURCES
- 404 SAFETY AND PUBLIC HEALTH REQUIREMENTS
- 405 ACCESS ROADS AND TRAFFIC CONTROL
- 406 SITE CLEARANCE AND REMOVAL OF TOPSOIL AND OVERBURDEN
- 407 SELECTION, MIXING AND STOCKPILING OF MATERIALS
- 408 PRE-SELECTION OF MATERIALS
- 409 PROCESSING
- 410 MATERIAL UTILISATION
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SECTION 400 - QUARRIES, BORROW PITS, STOCKPILE AND SPOIL AREAS

401 GENERAL

Unless otherwise stated in the contract, it is the responsibility of the Contractor to select the sources of rock/stone for pavement materials (such as sub base, base course, asphalt concrete/bituminous base/binder and wearing courses, chippings for surface dressing and other wearing courses); stones for masonry works, aggregates for mortar and concrete; natural/suitable materials, such as fill material, for the construction of embankments; gravel for road sub base and shoulder. Such sources shall be designated as rock quarries, river quarries/alluvial deposits, quarries and borrow pits and are defined in Clause 402. Certain rock quarries, quarries, alluvial deposits, borrow pits may have or have been identified and permission received from concerned authorities 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 clauses of this section of the Technical Specifications for additional rock quarries, quarries, alluvial deposits, borrow pits to be identified and located by the Contractor during the contract. The Contractor during execution of the contract can explore further suitable material sources and get approval on their extraction from concerned authorities, and materials from such sites could be permitted by the Engineer depending upon their suitability to meet the requirements of the Technical Specifications.

Stockpile and spoil areas shall be located by the Contractor subject to the approval of the Engineer.

402 DEFINITIONS

(1) Rock Quarry

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

(2) Quarry

A quarry is an open surface working from which stone or aggregates 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 aggregates 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 the works are dumped within or beyond the road reserve as indicated on the Drawing or directed by the Engineer.

403 LOCATING MATERIAL SOURCES

- (1) The Contractor shall be responsible for locating all material sources and for obtaining approval, the acquisition or renting of all land required for rock quarries, quarries, alluvial deposits, 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 under the following circumstances:

- (a) it is not approved from the concerned authorities;
 - (b) it will have a detrimental effect on the environment;
 - (c) it would be very difficult to acquire;
 - (d) it is in or near an urban centre;
 - (e) it will require an access road which is excessively long;
 - (f) it has excessively thick layers of overburden;
 - (g) it covers too large an area; and
 - (h) it would constitute a danger to the public
- (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 issuance of 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 of 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 giving details of:
 - (i) type of land (government, community, private), details and plot/land boundaries
 - (ii) government land including required details and permission from concerned government authorities
 - (ii) private land including land owners' names and addresses, and other details, as required.
 - (iii) Dzongkahg, Geog, village, Land Record registration (i.e.Tharm number) for each plot;
 - (iv) local details such as buildings, fences, types and areas of cultivation and services, all agreed with the concerning 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, as available.
- (c) Details of the proposed access road route.
- (d) Technical information relevant to rock quarries, quarries, alluvial deposits, borrow pits, including:
 - (i) Summary of material investigation, indicating the alluvial deposits, the thickness of layers, thickness of overburden, lenticular beds, depth and configuration of the bedrock, etc., and in addition for rock quarries, the 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, Mica content, Organic matters), tests on the coarse fraction (LAA, AIV, ACV, FI, Bitumen Adhesive test), CBR test, or for quarry material, LAA, AIV, ACV, Bitumen Adhesive test, Specific Gravity, Water Absorption, as appropriate
 - (iii) Conclusions on qualities and quantities.
- (3) Where the Contractor uses an approved 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 require the Contractor to modify his requirements for any of the reasons outlined in Sub-clause 403(1) (b), (c), (d), (e), or (g).

Where rock quarries, quarries, alluvial deposits, or borrow pits, available for inspection at the time of the bidding, 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 that 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 be 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.

404 SAFETY AND PUBLIC HEALTH REQUIREMENTS

The Contractor shall comply with the relevant laws, rules and regulations in force including those of the Local Authority regarding public health and safety in respect of the operation of rock quarries, quarries, alluvial deposits, 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 unauthorised 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.
- (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 top soiled and left neat and tidy.

405 ACCESS ROADS AND TRAFFIC CONTROL

The Contractor shall comply with the provisions of Clause 106 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.

406 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 500 but measurement and payment shall be made in accordance with this Section.

All existing fences, trees, hedges and other features shall not be removed or otherwise dealt unless instructed by the Engineer. They shall be protected in accordance with Section 500.

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 spread 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 top soiling in accordance with Section 1900.

407 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 Clauses 408 and 409 or other relevant Sections of those Specifications.

The Contractor may be required to mix the selected materials by bulldozing into stockpiles and/or face loading by shovel. The stockpiles shall be formed at least six weeks before intended use of the materials 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 to 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 otherwise directed by the Engineer.

408 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 materials as instructed by the Engineer.

409 PROCESSING

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

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

The Contractor shall carry out site trials in accordance with Clause 307 using the Constructional Plant and methods proposed for selecting and processing the materials to demonstrate their suitability to achieve the materials requirements specified in the Technical 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 Technical 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 materials to the crushers.

(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 aggregates is required to meet the cleanliness requirements, and notably 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.

Sands 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:

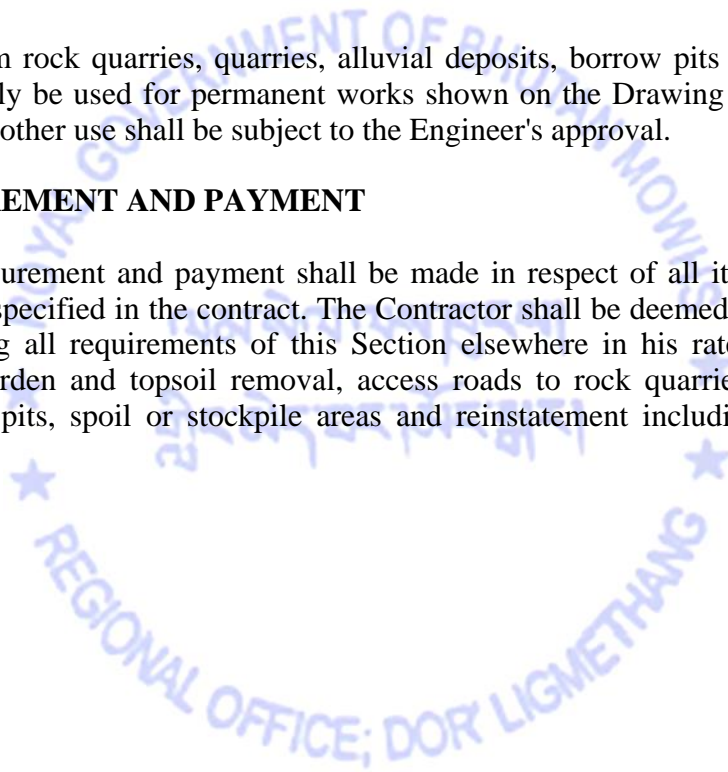
- (a) daily production
- (b) testing results, in accordance with the test schedules specified in the relevant Sections of these Specifications.
- (c) Incident occurred during the production, if any.

410 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.

411 MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made in respect of all items in this Section, unless otherwise 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 all 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.



SECTION 500 – CLEARING, GRUBBING AND REMOVALS

501 CLEARING AND GRUBBING

502 DISMANTLING CULVERTS, BRIDGES, OTHER STRUCTURES
AND PAVEMENTS

SECTION 500 – CLEARING, GRUBBING AND REMOVALS

501 CLEARING AND GRUBBING

(1) Scope

This 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 trees, bushes, shrubs, grass, weeds, other vegetation, anthills, rubbish, fences, top soil of thickness approximately 200 mm 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

All trees measuring less than 300 mm girth (measured at 1 m from the ground) within the road formation, including the stumps and roots shall be removed to a depth of not less than 150 mm below the sub-grade level or a minimum of 600 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 contract price, the Contractor 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 vegetable growth and accumulated rubbish of whatsoever nature and all other objectionable material shall be completely removed to a depth as specified.

Normally grubbing will be done for the stretches where embankments are to be constructed.

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, Felling of Trees

The Contractor shall take the necessary precautions to prevent damage to structures and other private or public property.

The Contractor shall carry out felling and cutting of trees with girth not less than 300 mm and above (measured at 1 m from the ground) manually or using equipments. Such individual trees shall be approved and marked at the site by the Engineer.

Due process must be followed and approval/permit for cutting trees must be obtained from the Department of Forests & Park Services who may require that trees be numbered, measured and marked in the presence of officials from the Department of Forests & Park Services. The copies of permits for tree felling and record of numbering, marking and felling of trees must be maintained by the Contractor. Cutting of such trees shall then be carried out by the Contractor and the timber stored at designated locations within the road Right of Way.

Felling and cutting of trees on the site and piling them off the site shall conform to the requirements of the Department of Forests & Park Services.

Wood, branches, twigs of trees and other useful material shall be property of the Government. The serviceable materials shall be stacked at sites in the manner as directed by the Engineer. All unserviceable materials shall be disposed off as per the instructions of the Engineer.

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 the road Right of Way. The roots of trees shall be dug at least up to 600mm from the ground level or 150mm below sub-grade level whichever is lower. All holes or hollows formed by digging up roots shall be carefully filled up with earth and properly compacted.

If felling of trees is carried out by bulldozer/excavator, power chain or any other suitable equipment shall be used to minimize any damages including environment.

(i) Blasting for Removal of Trees

The blasting operation, if any, for felling of trees shall be carried out strictly as per the guidelines given in DoR, Blasting Manual. All blasting operations shall only be done under careful supervision of trained/certified personnel and the contractor shall take all precautions as per Explosives Rules in force.

The contractor shall be responsible for any damage arising out of accident to the workmen, public or property due to storage, transportation and use of explosive during blasting operation.

For felling of trees, the holes shall be drilled inclined downward with a 30 mm auger. The location of holes shall be in parallel section of the trunk just above the butt. For trees up to 450 mm in girth one drill hole will be generally sufficient. For larger trees a series of equally spaced radial holes drilled within about 25 to 50 mm center to center shall be used.

The placing and quantity of explosives required shall vary with each tree and is governed by the age, type and girth. As general rule 1.2kg to 1.52 kg of explosives per square meter of cross section will be sufficient.

For removal of stumps or standing trees, placing of drill holes and quantity of explosives required shall vary with each tree and is governed by the size, type of stumps or tree, and the root system. Sandy or loose soil will require heavier charges than clay soil. The charge shall be placed centrally under the butt. But if there is only one taproot the explosives shall be placed under the fork formed by two of the largest surface roots. In stumps 900mm in girth or over, the charge shall be split and placed at two or more places around the tree.

(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.

Rock dumping shall be carried out at the places identified by the Engineer. The dump site shall be made good by placing soil layer and planting vegetation. The Engineer shall implement this operation using the provision of days work.

(e) Re-clearing of Vegetation

When portions of the road reserve, borrow or other areas have been cleared in accordance with the Technical 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 re-cleared.

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

(4) Measurement

No separate payment will be made for clearing and grubbing and felling of tress. It shall be deemed to have included in the rates of the relevant items for complying with the requirements of this Section

502 DISMANTLING CULVERTS, OTHER STRUCTURES AND PAVEMENTS

(1) Scope

This work shall consist of removing as hereinafter set forth existing culverts, 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, buildings and other structures which are within the road and which are designated for removal, shall be removed up to 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 and 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 become the property of the Employer. In general, abutments 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 a usable condition.
- (f) Salvaged reinforced concrete pipes, steel pipes, other structures shall be stored at places as directed by the Engineer or as shown in the Drawing. Structures or portions thereof which are specified in the contract for re-erection shall be stored in separate piles.
- (g) Timber from old structures which is designated by the Engineer as materials to be salvaged shall have all nails and bolts removed there from 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 or un-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 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.

(4) Dismantling Other Structures

In removing 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.

(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

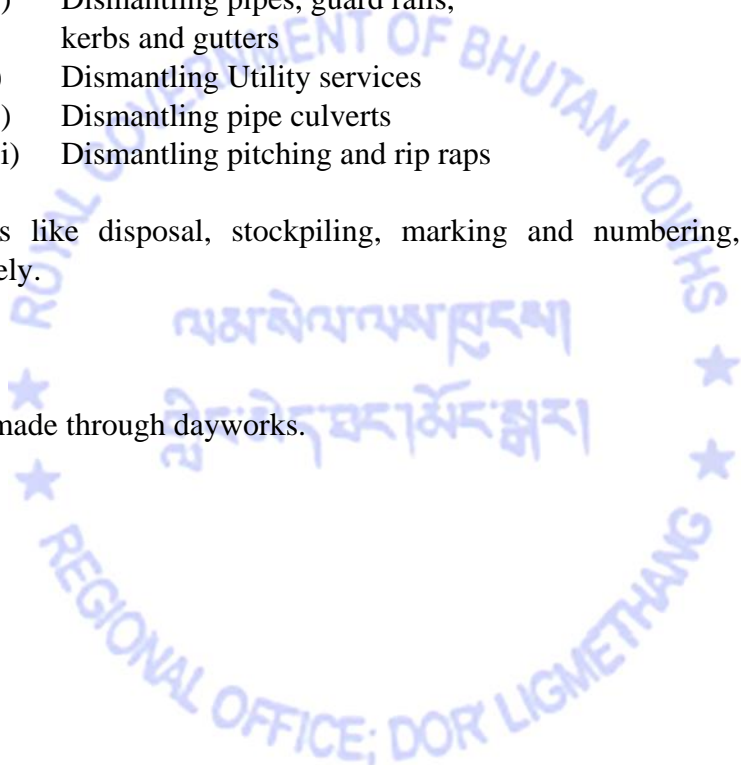
Prior to commencement of dismantling, the work of dismantling structures shall be measured in the units given below:

	<u>Type of Work</u>	<u>Unit</u>
(i)	Dismantling brick/stone masonry/ concrete (plain and reinforced)	cu.m.
(ii)	Dismantling gabion	cu.m.
(iii)	Dismantling timber structures	cu.m.
(iv)	Dismantling pipes, guard rails, kerbs and gutters	lin. m.
(v)	Dismantling Utility services	lump sum
(vi)	Dismantling pipe culverts	no.
(vii)	Dismantling pitching and rip raps	sq. m.

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

(7) Payment

Payment will be made through dayworks.



SECTION 600 - EARTHWORKS

- 601 SCOPE
- 602 DEFINITIONS AND GENERAL REQUIREMENTS
- 603 CLASSIFICATION OF EXCAVATED MATERIALS – **NOT APPLICABLE**
- 604 EXPLOSIVES AND BLASTING
- 605 EXCAVATION IN CUTTING
- 606 EXCAVATION BELOW EMBANKMENTS AND BELOW FORMATION LEVEL IN CUTTINGS
- 607 EXCAVATION FOR FOUNDATION, DITCHES, PAVEMENT, SLOPES, LANDSLIDE
- 608 REFILLING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLINGS TO STRUCTURES
- 609 FORMING OF EMBANKMENT AND OTHERS AREAS OF FILL
- 610 COMPACTION OF EMBANKMENTS AND OTHER AREAS OF FILL/BACKFILL
- 611 COMPACTION TRIALS
- 612 BENCHING
- 613 FINISHING OF SLOPES
- 614 EARTHWORKS TO BE KEPT FREE OF WATER
- 615 WATERCOURSES
- 616 FILLING EXISTING WATERCOURSES
- 617 PROCESS CONTROL
- 618 MEASUREMENT
- 619 PAYMENT

SECTION 600 – EARTHWORKS

601 SCOPE

This Section covers the works related to the roadway excavation (with or without blasting), roadway filling, excavation for foundation (with or without blasting), backfilling, excavation for drains, channels, intercepting drains etc. The works shall consist of excavation (with or without blasting), transport and disposing of all unsuitable and excess materials and excavating, hauling, placing and compacting suitable materials, from areas of excavation or borrow, all as required to construct the graded areas, embankments, roads, drainage, building construction sites and parking, or other fill area. The work shall be done in accordance with these specifications and in conformity with the lines, levels, grades, dimensions and typical cross-sections shown on the Drawings and as directed by the Engineer.

Suitable materials taken from excavation shall be used in the formation of embankment, subgrade, or for backfilling, or construction of structures all as indicated on the Drawings or as directed by the Engineer. When the volume of suitable excavated material exceeds that required to construct the works to the grades indicated, the excess shall be hauled, disposed with proper soil management at safe tipping sites as directed. When the volume of excavation

is not sufficient for constructing the works to the grades indicated, the deficiency shall be supplied from the borrow areas.

602 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 materials 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 road right of way except 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 excavation as stated above, 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 indicated on the Drawing.
- (ii) Excavation and removal or partial removal of existing pavement.
- (iii) Excavation and disposal of landslides, 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) 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 earthwork 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 turf acceptable for turving.
- (ii) "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 Clauses 609 and 610 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 swamps, marshes or bogs;
 - (b) Peat, logs, stumps, perishable material, organic clays;
 - (c) Material susceptible to spontaneous combustion;
 - (d) Material in a frozen condition; materials classified as such, if otherwise suitable, shall be classified as suitable when unfrozen.
 - (e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45;
 - (f) Any such materials unless otherwise permitted in the contract
 - (iv) "Rock Fill" shall consist of hard material of suitable size for deposition and compaction as given in Clause 609 and also may comprise rock as defined in Clause 603 and broken stones.
 - (v) "*Cohesive Soil*" is defined as fine grained soil, which is plastic within a moderate to wide range of water content. Dry specimens are very hard, and no powder can be detached by rubbing the surface of dried pots with the fingers. Cohesive soils are formed due to chemical weathering of rocks. Example: clay, plastic silt, etc.
 - (vi) "*Cohesionless Soil*" is defined as fine or coarse grained aggregates of rounded sub-angular or angular fragments of more or less unaltered rocks or minerals, which are formed due to physical disintegration of rocks and which is non-plastic in nature. Example: sand, gravel etc.
 - (vii) "Well Graded Granular Material" consisting of gravel and/or sand shall conform to Clause 609.
 - (viii) "Uniformly Graded Material" includes sands and gravels with a uniformity coefficient of 10 or less.
- (3) Prior to the commencement of any excavation, the Contractor shall satisfy himself as to the circumstances at the site and of all and the various materials, obstructions, strata, water streams including the possibility of floods, etc., and of all other items and things liable to affect or be encountered in the excavation necessary for the proper construction of the works. The rates priced in the Bill of Quantities shall provide for these circumstances.
- (4) The Contractor shall ensure that earthwork operation do not cause interference to the public. If excavations are carried out within 5 m of buildings, the Contractor shall execute the work in a way that will minimize damage and disturbances. In general, vertically sided excavation will be required in such places and all necessary timbering or other support shall be provided. Under-excavation of excavation sides will not be permitted.
- (5) 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.

- (6) Material in surplus to the total requirements of works, and all unsuitable materials shall, unless the Engineer permits otherwise, be run to spoil dumps.
- (7) 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.
- (8) The Contractor shall make his own arrangements for the stockpiling of top-soil and/or suitable material.
- (9) At all times the Contractor shall ensure that earthworks are not damaged by weather or traffic. In the event of such damage occurred, 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 without extra cost to the Employer.

- (10) Prior to commencement of any earthwork, the work shall be set out where required as specified in Clause 107 following the clearing and grubbing as per Section 500 and a 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.
- (11) Work on embankments and/or cuttings 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.
- (12) 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.

603 CLASSIFICATION OF EXCAVATED MATERIALS – NOT APPLICABLE

The excavated materials shall not be classified as soil or rock for the payment purpose. All incidentals involved in the excavation of road formation (be it rock or soil) shall be deemed included in the relevant item.

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

604 EXPLOSIVES AND BLASTING

(1) General

The procurement, transportation, storage, use, account and disposal of balance and defective explosive materials shall be strictly in accordance with DoR “Blasting Manual” and Explosive Rules in force, which is available at DoR Head Office and the by-laws issued by the Ministry of Home & Cultural Affairs, RGoB 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.

In areas where blasting is necessary, it shall be carried out in a controlled 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) Materials, Tools and Equipment

All the materials, tools and equipment used for blasting operations shall be of 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 in order to permit sufficient time to the firer to reach to a safe place before explosion takes place. Detonators shall be capable of 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 safely 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. The Contractor shall employ blasters experienced in controlled blasting and these blasters must be in possession of a current blasting certificate or should recently have participated in training for Controlled Blasting organized by Department of Roads.

(4) Blasting Operations

Explosives shall be used in the quantities and manner recommended by the manufacturers. 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 in 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 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 of 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 settlement 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 of 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 damage/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 from the flagged area at least 10 minutes before the firing. A warning siren should be 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 Blasting Manual of DOR shall be carried out to ensure that blasting damage 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) 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 hole 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.

605 EXCAVATION IN CUTTING

- (1) Clearing and grubbing shall be performed as specified in Section 500.
- (2) Excavation shall be carried out true to the line and levels and where blasting is to be resorted to, the same shall be carried out in accordance with Clause 604.
- (3) While executing excavations, the Contractor shall take adequate precautions against soil erosion and water pollution.
- (4) All suitable excavated materials shall be used in construction of the roadway to the extent as required.
- (5) Hauling of material from cuttings or borrow pits to embankments or other areas of fill shall proceed only when sufficient plant or labour is operating at the place of deposition to ensure that adequate spreading and compaction of material can take place.
- (6) 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 609 and 610.
- (7) The slopes of cutting shall be cleared of all rock fragments which move when pricked by a crow-bar, 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.

- (8) 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.
- (9) 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 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.

606 EXCAVATION BELOW EMBANKMENTS AND BELOW FORMATION LEVEL IN CUTTINGS

- (1) Where any unsuitable material below the natural ground level under proposed embankments or below formation level in cuttings 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 or capping layer 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 approved non-plastic well-

graded granular material having maximum size of not greater than 75mm. 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 609 and compacted as per Clause 610.
- (3) If after the removal of material as specified in Sub-clause 606 (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.

607 EXCAVATION FOR FOUNDATION, DITCHES, PAVEMENT, SLOPES, LANDSLIDES

1. Excavation for Foundation

(1) Scope

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 protection 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 foundations; trimming bottoms of excavations; and clearing up the site and the disposal of all surplus material. No portion of the work shall be covered unless inspected by the Engineer. The Contractor shall give a minimum of 24 hours notice in writing to the Engineer for each item of work to be covered or buried.

(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 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 resorted to, the same shall be carried out in accordance with Clause 604.

(3) Dewatering, Diversion of Flow and Protection

Normally, open foundations shall be laid dry. Where water is encountered in excavation due to stream flow, seepage, springs, rain or other reasons, the Contractor shall take adequate measures 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 slopes 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 dewatering and protection arrangements and for the quality and safety of the works.

Pumping from 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 condition 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 the Contractor carries out excavation deeper than that shown on the Drawing or as otherwise ordered by the Engineer, the Contractor shall make up the extra depth with concrete or masonry 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 M10 up to top level of rock or as instructed by the Engineer.

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. The Contractor shall give a minimum of 24 hours notice in writing to the Engineer for each item of work to be covered or buried.

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 foundation pits shall be securely fenced, provided with proper caution signs and marked with red lights/reflectors at night to avoid accident as per Sub-clause 105 (5).

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

(7) Removal of Shoring and Protection

All shoring, sheeting, bracing used in the foundation and protection 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 work.

2. Excavation for Ditch, Clearing of Existing Drains and Channels

Ditch excavation shall consist of excavation for drains, channels, or any other type as designated on Drawings or as directed by the Engineer. The work shall be performed in the proper sequence with other construction. The location of all ditches shall be established on the ground before starting construction of adjacent works. Suitable excavated material shall be placed in fills or stockpiles while unsuitable or surplus material shall be placed in spoil areas or as directed by the Engineer. Intercepting ditches shall be constructed prior to the starting of adjacent excavation operations. The excavation operations shall be carried out as required to secure a finish true to line, elevation and cross section, as designated.

Ditches constructed in the works shall be maintained to the required cross-section and shall be kept free from debris or obstructions until completion of the contract. As necessary, sufficient openings shall be provided through spoil banks to permit drainage from adjacent lands. No extra payment shall be made for ditches constructed in the works.

Existing drains and channels where shown on the Drawings or as directed by the Engineer, shall be cleared by removing vegetation growths and debris deposits. The sides shall be trimmed throughout and the bottoms uniformly graded and the ditches kept clean and trimmed and maintained for the period of the Works. Unsuitable material removed from existing drains, channels shall be disposed off in spoil areas designated by the Engineer.

3. Excavation (Scarification) for Pavement

During the subgrade preparation, if unsuitable materials are encountered, it shall be excavated and disposed off in designated location and the site shall be replaced with selected/suitable materials as capping layer, the density and moisture content of which is the same as the other part of the subgrade.

Where shown on the Drawings or as directed by the Engineer the existing pavement surfacing or pavement layers in carriageway and shoulders shall be scarified, transported and stockpiled at designated area for reuse or disposed to spoil. The surface after scarification shall be prepared to meet the requirements of Section 900 of the Technical Specifications. It will be broken, if needed, mixed to achieve required grading of base, sub base including adding extra base, sub base materials as required, watered and laid to required profiles and compacted in its final position as directed by the Engineer.

4. Excavation for Slopes and Removal of Landslides

Where shown on the Drawings or as directed by the Engineer the excavation shall be carried out for slopes in widening of road or curves, removal of unstable slopes/landslide, trimming of slopes, etc. The earthwork for removal of landslides shall be other than those encountered in routine maintenance of road as specified in Clause 109 of the Specifications. Suitable excavated material shall be placed in fills or stockpiles while unsuitable or surplus material shall be placed in spoil areas or as directed by the Engineer.

608 REFILLING OF FOUNDATION PITS AND TRENCHES, REMOVAL OF SUPPORTS AND FILLING TO STRUCTURES

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

(1) Materials

(a) Pervious/Graded Backfill

Filter layer behind the structures shall consist of boulder (size below 200 mm) filling or unless otherwise specified in the contract, it shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof. It shall conform to the grading limits set out in Table. 6.1.

Table 6.1: Grading Limits of Pervious Backfill

Sieve Size (mm)	Percentage Passing by Weight		
	Class 1, Fine Grade	Class 2, Medium Grade	Class 3, Coarse Grade
40	-	-	95-100
20	-	90-100	50-100
10	100	40-100	15-55
4.75	90-100	25-40	0-25
2.36	80-100	18-33	0-5
1.18	50-95	-	-
0.60	30-75	5-15	-
0.300	10-30	0-7	-
0.150	1-10	-	-
0.075	0-3	0-3	0-3

Piping ratio $\frac{D_{15}(\text{filter})}{D_{85}(\text{soil})} < 5$

Permeability ratio $\frac{D_{15}(\text{filter})}{D_{15}(\text{soil})} > 5$

Mean ratio $\frac{D_{50}(\text{filter})}{D_{50}(\text{soil})} < 25$

Where D_{15} and D_{50} (filter) are used to designate the size of sieve passing 15 percent and 50 percent respectively size of filter material (i.e. the size of the sieve that allows 15 percent and 50 percent respectively by weight of the filter material to pass through it).

(b) Common Backfill

Common backfill materials other than pervious backfill shall be suitable material as defined in Sub-clause 602 (2) or as directed by the Engineer.

(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 610. 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.

609 FORMING OF EMBANKMENT AND OTHER AREAS OF FILL

- (1) The work shall consist of the construction of embankment, filling on other areas and backfill not specified elsewhere by providing materials 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 75mm for general earth fill.
- (2) The limits of embankment shall be built sufficiently wider than the design dimension to facilitate in achieving required compaction nearby outer faces of the embankment. The surplus material shall be trimmed to 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 610. 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 610 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 optimum moisture content 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 placing material. If these parameters are found to be out of the specified limits, the same shall be made good. Where water is required to be added in such construction, it shall be sprinkled uniformly and thoroughly mixed in soil by blading or harrowing until 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 until it is in a suitable physical condition for re-use; or
 - (iii) Make good the material by mechanical or chemical means to improve its 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 806.
- (7) Rock used 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 610. 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 of 0.05 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 embankments 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 from the structure as 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 carriageways 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 803.

610 COMPACTION OF EMBANKMENTS AND OTHER AREAS OF FILL/BACKFILL

- (1) The Contractor shall obtain the Engineer's 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 6.2 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 rock fill. Formation level in this context shall mean top of subgrade.

Table 6.2: Depth and Degree of Compaction

Location	Depth below Formation Level (mm)	Minimum Compaction (% MDD Heavy Compaction)
Roadway Embankment	0-300	95
Roadway Cut	0-300	95
Backfill for soil reinforced walls with gabion facia	0-300	95
All other roadway fill and backfill not separately specified	-	93

- (3) Compaction shall be undertaken to the requirements of Table 6.3 by approved compaction equipment.

Table 6.3: Compaction Requirements

Type of Compaction Equipment	Category	Cohesive Soil		Well Graded granular and Dry cohesive soils		Uniformly Graded materials	
		Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes
Smooth Wheeled Roller	<u>Load per mm. width or roll</u> 2.14 - 2.67 kg.	130	8	130	10	Unsuitab	

Type of Compaction Equipment	Category	Cohesive Soil		Well Graded granular and Dry cohesive soils		Uniformly Graded materials	
		Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes
	2.68 - 5.35 kg.	130	6	130	8	Unsuitable	
	More than 5.35 kg.	130	4	150	8	Unsuitable	
Grid Roller	<u>Load per mm. width of roll</u>						
	2.65 - 5.35 kg.	150	10	Unsuitable		150	10
	5.36 - 8.00 kg.	150	8	130	12	Unsuitable	
	More than 8.00 kg.	150	4	150	12	Unsuitable	
Pneumatic Tyre Roller	<u>Wheel Load</u>						
	1000 – 1500 kg.	130	6	Unsuitable		Unsuitable	
	1500 – 2000 kg.	150	5	Unsuitable		Unsuitable	
	2000 – 2500 kg.	180	4	130	12	Unsuitable	
	2500 – 4000 kg.	230	4	130	10	Unsuitable	
	4000 – 6000 kg.	305	4	130	10	Unsuitable	
	6000 – 8000 kg.	355	4	150	8	Unsuitable	
	8000 – 12000 kg.	405	4	150	8	Unsuitable	
More than 12000 kg.	455	4	180	6	Unsuitable		
Vibratory Roller	<u>Static Load per mm. width of Vibratory roll</u>						
	0.27 - 0.44 kg.	Unsuitable		75	16	150	16
	0.45 - 0.71 kg.	Unsuitable		75	12	150	12
	0.72 - 1.25 kg.	100	12	130	12	150	6

Type of Compaction Equipment	Category	Cohesive Soil		Well Graded granular and Dry cohesive soils		Uniformly Graded materials	
		Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes	Maximum depth of Compaction Layer (mm)	Minimum No. of Passes
	0.26 - 1.78 kg.	130	8	150	8	200	10
	1.79 - 2.32 kg.	150	4	150	4	230	12
	2.33 - 2.86 kg.	180	4	180	4	255	10
	2.87 - 3.56 kg.	200	4	200	4	280	8
	3.57 - 4.28 kg.	230	4	230	4	305	8
	4.28 - 5.00 kg.	225	4	225	4	305	6
Vibrating Plate Compactor	<u>Static Pressure under base plate</u>						
	0.088 - 0.105 kg/sq.cm	Unsuitable		Unsuitable		75	6
	0.106 - 0.123 kg/sq.cm	Unsuitable		75	10	100	6
	0.124 - 0.141 kg/sq.cm	Unsuitable		75	6	150	6
	0.142 - 0.176 kg/sq.cm	100	6	130	6	150	4
	0.177 - 0.211 kg/sq.cm	150	6	150	5	200	4
	More than 0.211 kg/sq.cm	200	6	200	5	255	4
Vibro-tamper	<u>Weight</u>						
	50 - 63 kg.	100	3	100	3	150	3
	64 - 75 kg.	130	3	130	3	200	3
	More than 75 kg.	200	3	150	3	230	3
Power Rammer	<u>Weight</u>						
	100 kg. - 500 kg.	150	4	150	6	Unsuitable	
	More than 500 kg.	280	8	280	12	Unsuitable	

- (4) Each layer of rock used to fill in embankments shall be spread and leveled in accordance with Sub-clause 609(7) and systematically compacted.

- (5) Layers of material other than rock fill 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.
- (6) 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.
- (7) In cut areas, the subgrade shall be processed as necessary and compacted to the depth and compaction requirements as given in Table 6.1 and Table 6.2. In the event that the Contractor is unable to achieve the minimum compaction requirements below formation level he shall excavate and recompact in layers as necessary.
- (8) Where it may be impracticable to use 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.

611 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 rock fill to be used and compacted in the Works. The Contractor shall carry out all necessary laboratory and field testing as required by the Engineer and shall submit the results of all tests to the Engineer. 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 specified degree of compaction. The Contractor's proposals shall include reference to the types of equipment, the operating weights and tyre 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 procedures 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.

612 BENCHING

- (1) Where embankments 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 the first layer and compacted to the specified density simultaneously with the first layer of embankment material placed.
- (2) Where existing embankments 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.

613 FINISHING OF SLOPES

The slopes of cuttings shall be trimmed to neat line and to a standard that is attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones and nests of loose material shall be removed especially in solid rock cuts which must be completely free of such material. The final surface batters must not be absolutely smooth, but shall have a slightly rough surface that would be suitable for subsequent grassing or for the natural vegetation to be established on the surface.

Fill slopes shall be finished to neat lines with all loose rocks and non compacted material removed. The degree of finish required shall depend on the nature of the material used for the fill slopes but shall be as smooth as is consistent with the material involved and good workmanship. No boulders in excess of 150 mm in size will be permitted and isolated large boulder in otherwise smaller size material shall not be allowed to project out of the surface. In the case of rock fill soft material shall be worked into the interstices between the rock on the surface of the slope.

Except in solid rock the tops and bottoms of all slopes, including the slopes of drainage ditches, shall be rounded as indicated on the Drawings or as directed by the Engineer. Slopes at the junctions of cuts and fills shall be adjusted and warped to flow into one another, or into the natural ground surfaces, without any noticeable break.

Cut and fill slopes shall be finished to a uniform appearance without any noticeable break readily discernible from the road. The degree of finish required for all fill slopes and for cut slopes flatter than 1 in 4 shall be that obtainable by motor grader.

The slopes of cuts and fills which are designated for grassing shall, after finishing, be prepared for grass planting and /or top soil for grass planting.

All trimming of side slopes of cuttings shall be completed before any work on the sub base is commenced inside such cuttings.

614 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 the permanent outlet for the drainage system. Adequate means for trapping silt shall be provided on temporary systems while discharging into permanent drainage systems.

615 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.

616 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 vegetative growths and soft deposits and filled in with suitable materials deposited and compacted as specified in Clauses 609 and 610.

617 PROCESS CONTROL

- (1) Throughout 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 cum 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 cum of material.
- (2) In addition to the foregoing tests, the Contractor shall carry out field 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 sqm (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 609(5) to ensure that the requirements of Clause 610 are met with.

618 MEASUREMENT

- (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) All roadway excavation including road formation shall be measured in running meters.
- (3) Foundation excavation, filling and backfilling compacted in place shall be measured in cubic metres.

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.

No measurement shall be made for any excavation other than the limited excavation described above. Excavation over increased width or length, cutting of slopes, 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.

No separate measurement shall be made for any quantities of finishing of slopes and preparatory work for formation of embankment and other areas of fill.

- (3) Use 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 to have been included in the measurement of the concerned item.

619 PAYMENT

- (1) Various classes of earthworks i.e. roadway excavation shall be paid in running meters. Roadway filling, backfilling, and others measured as described above shall be paid at contract unit rate of the respective item.
- (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 the Technical Specifications. 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.
- (3) Payment for scarifying, processing, laying, profiling and compacting existing pavement, and preparation of surface for laying of pavement layers shall be made at the contract unit rate, which shall be the full and the final compensation to the Contractor as per TS. No separate payment shall be made to the Contractor for any extra base, sub base material required to be added to scarified sub base material to prepare it to comply the requirements of the specifications; reworking; placing and compacting for the final position.

620 ROCK FILL EMBANKMENTS

a) Scope

Rock fill embankments are to be constructed as shown on the drawings. In general, such construction will involve filling of deep gullies with suitable coarse rock material excavated from roadside cuttings.

Because of the typical depth and inaccessibility of such gullies, compaction will only be possible once the rock fill level approaches the road formation level.

b) Rock fill Material Requirements

The source of the most suitable and economical rock fill shall be jointly agreed between the contractor and the Engineer. In general this will be covered under Earthworks – Rock, including necessary lead to the rock fill site.

- i) Rock fill material shall have very low plastic soil content. Fines should be mostly from rock rather than soil.
- ii) Should have <15% minus 4.75mm (based on visual assessment/field grading)
- iii) Oversize (>0.65m nominal) should all be broken (rock breaker) and distributed evenly
- iv) Should be reasonably well graded after spreading layer. If very coarse/broken oversize, mix in smaller material to reduce voids
- v) Should give uniform appearance after spreading of layer
- vi) Should have no large rock protruding through surface of any layer.

For dumping of materials, the above references to compaction and layers are not applicable.

c) Typical Construction Process

The typical construction process is as listed below. This will differ depending upon the characteristics of individual sites. The actual methodology to be adopted shall be as agreed between the Engineer and the contractor.

- i) Clear the site of vegetation (grubbing is not required)
- ii) Construct toe wall of either masonry, boulders or gabions as dictated by site conditions and requirements. The details of the location and type of such walls are to be approved by the Engineer.
- iii) Protect the toe wall against damage by falling/rolling boulders during rock fill placement. Where necessary, this shall comprise manually placed dry stone protection against the wall of at least 1m in thickness.
- iv) Dumping of coarse rock fill (without compaction). Initial dumping should consist of the coarsest material available to provide a toe region highly resistant to any scouring.
- v) Once the rock fill reaches a level that is accessible to construction plant (as jointly agreed by the Engineer and the contractor), commence track rolling by a minimum “D6” sized dozer or minimum 20 tonne excavator. Any necessary ramps of cutting required for such access shall be paid separately.

- vi) Compaction by track rolling shall comprise 700mm layers with 5 passes across the full layer extent. The maximum size of rock to be used shall be such that no single rock shall protrude through the surface of the compacted layer.
- vii) As the rock fill level advances, benching (in soil) of the gully sides shall be undertaken as shown on the drawings.
- viii) Verification/assessment of compaction achieved shall be based on the US Army Corps of Engineers standard procedure. In summary, this consists of measuring the average settlement of a trial layer through each of 8 passes of track rolling. This is measured by means of 5 or more steel settlement plates and level survey before and after each consecutive pass. In general, the settlement after 5 passes should be greater than 80% of the settlement at 8 passes (or near refusal). The plotted relationship between passes and settlement for representative materials can then be used to verify compaction. The frequency of such testing shall be as directed by the Engineer.
- ix) Batter treatment shall be as shown on the drawings. Dumped rock should be carefully placed to as uniform slope as possible, and be approximately at the natural angle of repose. Some manual packing or batter treatment may be directed by the engineer for the dumped rock sections. This shall be paid separately – provided dumping has not been haphazard. For compacted rock fill, the batter shall comprise interlocked larger size rip-rap (nominally greater than 500mm) on the face. As directed by the Engineer, this may be constructed in the form of a rock cascade.
- x) The top of the rock fill shall have a 10 kN/m tensile strength non woven geotextile and above the geotextile, a minimum thickness of soil cushion (filling) beneath the pavement. In many locations, the section immediately above the rock fill is to include a precast inverted “U” box culvert (with cast in-situ base slab) or hume pipe. Appropriate levels for the rock fill and cushion/culvert backfill where applicable will be provided by the Engineer.
- xi) With predominantly dumped rock fill material in the lower part of the rock fill, post construction settlement/consolidation is expected to be significant. For this reason, construction of any precast culverts and/or road base and bituminous surfacing shall be deferred until at least 3 months from the time of completion of the rock fill. During this period rainwater can be allowed to discharge through or over the rock fill (discharges are comparatively low for all rock fill). The Engineer may direct that settlement readings are taken at regular intervals (bi-monthly or monthly).

d) Payment

Payment for rock fill construction shall comprise:

- i) Track rolling as described in Clause c) on a cubic meter basis
- ii) Separation, necessary stockpiling and placement (by excavator) of coarse rip-rap boulders (greater than nominal 500mm size) on the batters – on a cubic meter basis.

All rock fill materials shall come from roadside excavation and shall not be paid separately. Clearing, construction of walls if required, benching and necessary (approved) excavation; necessary labour (for correction of batter profile); and provision of soil and cushion filling and selected backfill for culverts shall be paid under relevant items under the contract.

SECTION 700 – PROCESS CONTROL TESTING & TOLERANCES

- 701 HORIZONTAL ALIGNMENTS, SURFACE LEVELS AND SURFACE REGULARITY OF PAVEMENT COURSES
- 702 ADVERSE WEATHER WORKING
- 703 USE OF SURFACES BY CONSTRUCTIONAL TRAFFIC
- 704 CARE OF WORKS
- 705 MEASUREMENT AND PAYMENT

SECTION 700 - PROCESS CONTROL TESTING & TOLERANCES

701 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 the Technical Specifications.

(2) Tolerances

(a) Horizontal Alignments

Horizontal alignments shall be determined from the centreline of the pavement surface as shown or calculated from the Drawing. The centreline of the pavement surface as constructed, and all other parallel alignments, shall be correct within a tolerance of ± 13 mm therefrom.

(b) Thickness of Pavement Layers

The average thickness of any pavement layer measured at five consecutive points at every 20m 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 from the corresponding level calculated from the Drawing by more than the tolerances shown in Table 7.1.

For checking compliance with Table 7.1 measurements of surface levels shall be taken at points to be selected by the Engineer at 12.5m centres longitudinally and at 2m centres transversely. At junctions, the grid point spacing 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 centreline of the road. The maximum allowable deviation of the surface below the

straight-edge shall not deviate from that shown on the Drawing by more than the tolerances shown in Table 7.1.

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 7.1. If tolerances given in Table 7.1 for level and straight edge are not in agreement, the tolerances given for straight edge shall prevail.

Table 7.1: Tolerances for Level and Surface Regularity

Layer	Level mm	Straight edge mm	Slope or Crossfall %
DBM/Bituminous Wearing Course	± 10	6*	± 0.25
Bituminous Binder Course	± 10	6	± 0.25
Base	± 10	6	± 0.25
Sub base	± 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 4mm.

(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 the 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 Cuttings and Embankments

The tolerance permitted in the width of the bottom of cuttings shall be 200 mm between the centreline of the road and the toe of the cutting slope.

The width of embankments measured horizontally and perpendicular to the centreline 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 from the specified in the drawing by ± 25 mm.

(3) Rectification of Earthworks and Pavement Layers Exceeding Tolerances

Where any tolerances in Sub-clause 701 (2) are exceeded, 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 cut 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 cut slope is slacker, the natural ground slope above top of the cutting and the adjacent cut slopes in both sides of the slacker slope shall be so trimmed that the entire cut slopes match together and they are stable. Where an embankment slope 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 600.

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 600.

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 tolerance, 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 to comply 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 Specifications. However, if needed, more tests shall be conducted to ascertain the extent of the area required to be reworked.

(c) Base and Sub base

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 with the Specifications. The area treated shall be at least 30m long and 3m wide or such area determined by the Engineer necessary to comply with the 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 5m 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 laying wearing course or re-laying 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 15m 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 701.

Notwithstanding the provisions of Sub-clauses 701 (2) and 701 (3) measurement and payment for earthworks and pavement works shall be made on the basis of the net-cross-Section and/or area basis whichever is applicable 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 as 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.

702 ADVERSE WEATHER WORKING

- (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 materials 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:
 - (a) 6 degree Celsius with a wind velocity of 25 km/hr
 - (b) 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 the 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 temperature 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 mornings and late evenings. Curing shall commence after placing of the concrete in order to prevent excessive loss of moisture.

703 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.

704 CARE OF WORKS

The general obligations for “Care of the Works” shall inter-alia include the following:

- (1) Materials 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 equipment, plants, labour and/or materials. In the case the roads are rendered dirty, they shall be cleaned immediately.

705 MEASUREMENT AND PAYMENT

No measurement and payment shall be made for the works required under this Section. 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 800 - SUBGRADES

- 801 SCOPE
- 802 DEFINITIONS
- 803 PREPARATION AND SURFACE TREATMENT OF FORMATION (SUBGRADE)
- 804 RIPPING OF EXISTING PAVEMENT LAYERS
- 805 SCARIFYING EXISTING PAVEMENT LAYERS
- 806 CAPPING LAYERS
- 807 MECHANICAL STABILISATION
- 808 MEASUREMENT
- 809 PAYMENT

SECTION 800 - SUBGRADE

801 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 materials, the improvement of in-situ materials by addition and mixing of selected materials.

802 DEFINITIONS

The following definitions shall apply to this section and other relevant sections of these Specifications:

(1) Formation Level

The top surface of the subgrade, which supports the construction of pavement.

(2) Subgrade

Up to 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 803.

(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 "stabiliser".

(5) Mechanical Stabilisation

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

(6) Treated Materials

Following the addition of stabiliser to the in-situ materials, the material is referred to as "treated material." Treated materials shall be mechanically stabilised.

803 PREPARATION AND SURFACE TREATMENT OF FORMATION (SUBGRADE)

Preparation and surface treatment of formation (subgrade) shall be carried out only after completion of all drainage works unless otherwise agreed by the Engineer and prior to laying the sub base or the base where no sub base 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 than 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 cuttings except otherwise instructed by the Engineer, according to the material encountered, loose materials of the embankments 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 cuttings and shall be compacted in accordance with the 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 required 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 300, 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 3000m² or part of it of each layer of compacted subgrade.

The field dry density shall be determined at least once per 500m² 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 3000m² 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 309 (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 805 to 806 of this Specification.

(3) Formations in Rock Cuttings

The subgrade in rock cuttings shall be regulated after trimming the rock excavation by a regulating course of minimum 150 mm compacted depth of natural materials complying with the requirements of natural material for sub base as specified in Sub-clause 900 (3).

The regulating course shall be laid, compacted and tested in accordance with Clause 901 and the surface regularity shall meet the requirements of Clause 700.

(4) Preparation of Formation for Rehabilitation Works

The formation (subgrade) shall be graded and compacted for construction of pavement in carriageway, shoulders, footpath, and lay-bys. Any soft areas shall be corrected as directed by the Engineer. The prepared surface shall be well cleaned and free from mud and slurry.

(5) Proof Rolling

All subgrade shall be proof rolled with a loaded scraper or truck with a minimum axle load of 8 tonnes. Proof rolling 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 proof rolling shall be at the Contractor's expense.

(6) Surface Regularity and Tolerances

The surface regularity and tolerances of the subgrade shall meet the requirements of Clause 701.

When each layer is completed the Contractor shall comply with the requirements of Clause 310 for requesting the Engineer's approval and protecting the layer.

804 RIPPING OFF EXISTING BITUMINIOUS SURFACE USING EXCAVATOR

The existing bituminous surface shall be ripped off using excavator/manual. The same shall be placed back on the full width of the subgrade and rolled as per Section 900 to construct an improved sub base of nominal 75-100 mm thickness.

805 SCARIFYING OF EXISTING BITUMINIOUS SURFACE

Where embankment work is required in order to increase the level of road, the existing bituminous surface shall be scarified using excavator/manual before placing the fill materials over it.

806 CAPPING LAYER

Where shown on the Drawing or where in-situ material in the subgrade in cuttings 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 be excluded from the subgrade and that certain materials be set apart, 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 in capping layers shall be selected among soils classified as GW, GP, GC, SW in the Unified Soil Classification.

(2) Material Requirements

Materials 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 grading requirement for capping layer materials shall be as shown in Table 8.1

The material for use in the capping layers 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 maximum 6 %.

Table 8.1: Grading Requirements for Capping Layer Materials

Sieve Size (mm)	Percent passing by dry weight
50	100
37.5	80 – 100
20	60 – 100
4.75	30 – 100
1.18	15 – 75
0.3	9 – 5
0.075	5 – 15

(3) Laying and Compaction

The material shall be deposited in the layer of 150 mm compacted depths. Each layer shall extend over the full width of the embankments or cuttings and shall be compacted in accordance with the requirements specified in Sub-clause 803 (1) (a) to (d)).

(4) Proof rolling and Tolerances

Proof rolling and tolerances of capping layers shall be in accordance with Sub-clause 803 (5) and (6).

When each layer is completed the Contractor shall comply with Clause 310 for requesting the Engineer's approval and protecting the layer.

807 MECHANICAL STABILISATION

(1) General

The extent of the mechanical stabilisation shall be shown on the Drawing or as directed by the Engineer.

In-situ subgrade materials subject to mechanical stabilisation shall be generally soils classified as SM, ML, CL, MH, CH in the Unified Soil Classification 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 803 (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 Table 8.2.

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

Sand may be soils classified as SP, SW in the Unified Soil Classification system or Sand 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 8.2: Types 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
CH		SP,SW

(b) Stabilised Material Requirements

The amount of stabiliser shall be determined by the Engineer after laboratory test. The mechanically stabilised materials after mixing and compacting shall conform to the following requirements:

- 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 stabiliser to be added shall be generally between 15% and 25% in weight of the in-situ materials and shall be determined by the Engineer following laboratory trials, and site trials to be carried out by the Contractor in accordance with Section 300.

During the site trials, the control testing requirements shall be in accordance with Clause 307 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 graders, 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 300, it produces the material to the specified requirements.

(b) Preparation of the Layer

Before the stabiliser 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 stabiliser shall be uniformly spread over the width to be worked at the specified rate.

(d) Mixing and Watering

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 homogeneous mass.

Care shall be taken both during mixing and subsequent watering operations so that the underlying layer is not disturbed. No material from the underlying 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 a uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed 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 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 stabilizer and watering, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct loose thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

(5) Compaction and Finishing

(a) Thickness of Layers

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

(b) Compaction Requirements

The minimum density for mechanically stabilised 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 701. If the surface fails to meet the requirements of this Specification, the Contractor shall take corrective measures as set out in the appropriate part of Section 900 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 m² or part thereof of the subgrade the following properties shall be determined:

- Grading,
- Moisture Content,
- Atterberg limits,

- MDD (heavy compaction) and OMC,
- 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 m³ or part thereof and when in the opinion of the Engineer the nature of the material is changed.

- Grading,
- SE (sand equivalent)

(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:

- MDD (heavy compaction) and OMC,
- 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 m² or part 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 701.

(b) Amount of Stabiliser

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

808 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 metre by average end area method.
- (2) Preparation of subgrade 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 806 (1).

- (4) Mechanically stabilised subgrade shall be measured in cubic metre as described in Sub-clause 806 (1) and shall be exclusive of the measurement of the stabilisers.

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 100m five standard holes at the equal distances shall be dug 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.

809 PAYMENT

The subgrade construction with loose untreated/treated materials, formation in rock cutting, preparation of subgrade, capping layer, mechanically stabilised subgrade shall be paid at their respective contract unit rate which shall be the full and the final compensation to the Contractor for all the materials, labor and machineries involved as per Clause 116 and also for the cost of:

- (1) Arrangement of land for supply source of materials 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 803.
- (5) Proof rolling and testing.
- (6) All other operations including incidental costs necessary to complete the item as per this Specification.

SECTION 900 – GRANULAR SUB BASE (GSB)

901 GENERAL

This section covers the construction of mechanically stable sub base with suitable material.

The specification and requirements are based on the recommended criteria given by the UK Transport Research Laboratory's Overseas Road Note 31 – A Guide to the Structural Design of Bitumen-surfaced Roads in Tropical and Sub-tropical Countries.

902 SOURCES OF MATERIALS

Sub base materials shall be obtained from approved roadside excavation 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 400 in respect of borrow pits.

903 MATERIAL REQUIREMENTS AND POTENTIAL PROCESSING

The sub base material for this purpose shall be material from an approved source. The source may be river bed or pit gravels, rock quarry, alluvial deposits, crusher-run, or other naturally occurring granular materials meeting the requirements of these Specifications.

Partial processing may include such measures as the use of a bar “grizzly”, or mechanical screening to separate oversize material; crushing or use of a grid or cleated roller to reduce oversize; and/or blending or mechanical stabilization.

The sub base material after placing and compaction shall conform to the following requirements:

The grading of the sub base material after placing and compaction shall be a smooth curve within and approximately parallel to the envelope given in Table 9.1.

Table 9.1: Grading Envelope for Granular Sub base

Sieve size (mm)	Percentage Passing by Weight	
	Grading I	Grading II
75	100	-
53	-	100
26.5	55-75	50-80
4.75	10-30	15-35
0.075	<10	<10

The fraction passing 0.425 mm sieve shall have a Liquid Limit not more than 25, a Plasticity Index not more than 12 % and Linear Shrinkage not more than 6%.

The CBR of the material, after 4 days soaking, shall not be less than 30% at 97% MDD (Modified Compaction).

904 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 the Engineer on each main type of materials to be compacted in the Works. The length of the trial section shall be minimum 100 m unless otherwise specified by the Engineer. The Contractor shall carry out all necessary laboratory and field tests 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 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.

905 PREPARING UNDERLYING COURSE

The sub base shall only be constructed provided that the underlying subgrade layer conforms to the requirements specified in Section 800 of the Technical Specifications. Immediately before placing the material, the subgrade shall be checked for any damage or deficiencies, which shall be made good.

906 LAYING AND COMPACTION

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 Drawings 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 broken down to the grading specified in Clause 903. Any oversize material which cannot 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.

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 is required 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 tight and 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 corrective measures as set out in the appropriate part of Section 800 or such other action as directed by Engineer.

907 PROOF ROLLING

Unless otherwise directed by the Engineer, the Contractor shall proof roll 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 proof roller. Approval of the layer

shall only be given after the satisfactory completion of the proof rolling and any remedial measures shall be at the Contractor's expense.

908 SETTING OUT AND TOLERANCES

The layer shall be set out and constructed to the appropriate tolerances specified in Section 700.

909 DRAINAGE OF SUBGRADE AND SUB BASE

The subgrade and sub base 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 sub base, 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.

910 TESTING

(1) Process Control

The minimum testing frequency for the purpose of process control shall be as given in Table 9.2.

Table 9.2: Granular Sub base - Minimum Testing Frequency

Tests	One test in Every:	Minimum no of tests per section
Material:		
Gradation	200 m ³ or part thereof, and change in source	2
Atterberg Limits, Shrinkage	" " " " "	2
Maximum Dry Density and Optimum Moisture Content	1000 m ³ " " " "	2
Field Density and Moisture Content	500 m ² of each layer	2
Construction Tolerances:		
Surface Levels	10 m	-
Thickness	25 m	-
Width	200 m	-

(2) 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 not complying with the specified requirements shall be replaced with materials and/or workmanship complying with the specified requirements or be repaired to comply with the specified requirements.

911 MEASUREMENT

Payment for granular sub base will be on the basis of cubic metres of compacted volume. Compacted volume 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.

912 PAYMENT

The granular sub base construction shall be paid at the respective contract unit rate for the applicable haul/lead from the approved source and shall be full and final compensation to the Contractor for all the materials, labor and machineries involved as per Clause 116 to complete the work as per the Technical Specifications. In addition to the stipulations under Clause 116, 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 and to comply with the requirement of Sections 300 and 400.

SECTION 1000 - BASE COURSE

SECTION 1003 - WET MIX CRUSHED STONE BASE

1003.1 General

The work shall consist of laying and compacting clean, graded crushed stone aggregate material, premixed with water, to a dense mass on a prepared subgrade/sub-base/base or existing pavement as the case may be in accordance with the requirements of the Technical Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the Drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm.

1003.2 Materials

(a) Aggregates

The aggregate shall be either crushed stone or crushed gravel. The fine aggregate shall be screenings obtained from crushed stone or gravel. The crushed aggregate shall consist of hard, sound, durable and unweathered stone, rocks, and boulders crushed to specified sizes and shall be free from dirt or other objectionable matter and shall not contain soft or disintegrated pieces.

If crushed gravel is used, not less than 90 per cent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 10.3 and Clause 210 of these Specifications.

Table 10.3: Physical Requirements of Coarse Aggregates for Wet Mix Base Course

Test	Test Method	Requirements
1 * Los Angeles Abrasion value or * Aggregate Impact value	IS: 2386 (Part 4) IS: 2386 (Part 4) or IS:5640	Maximum 40 per cent Maximum 30 per cent
2 Flakiness Indices	IS : 2386 (Part 1)	Maximum 30 per cent
3 California Bearing Ratio	IS : 2720 (Part 16)	Minimum 80 per cent
4 Crushing Ratio	Manual counting & weighing	Minimum 80 percent

* Aggregate shall satisfy requirements of either of the two tests.

If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to the site as per IS: 2386(Part-5).

(b) Grading requirements

The aggregates shall conform to the grading given in Table 10.4.

Table 10.4: Grading Requirements of Aggregates for Wet Mix Base Course

Sieve Size (mm)	Per cent by weight passing
50	100
37.5	95-100
20	60-80
12.5	40-60
4.75	25-40
2.36	15-30
0.600	8-22
0.075	0-8

At least 40% of particles retained on a 12.5 mm screen must be angular, irregular or crushed faces.

a) Aggregate Hardness Criteria

Aggregate shall have a minimum soaked (overnight) Ten Percent Fines Value of 50KN or a maximum soaked Aggregate Impact Value of 40.

b) Plasticity of Fines

The fraction passing the 0.425 mm sieve shall have Plasticity Index (PI) not more than 6 %. As an alternative to testing of PI, a maximum Linear Shrinkage of 3% is applicable.

If the PI approaches the upper limit of 6% ($4.5 < PI < 6.0$), the fines content shall be restricted to the lower end of the grading range given in a) in accordance with the following criteria:

- i) A maximum PP (PI x percentage passing the 0.075mm sieve) of 60, and
- ii) A maximum PM (PI x percentage passing the 0.425mm sieve) of 90.

c) California Bearing Ratio (CBR)

The CBR of the material, after 4 days soaking, shall not be less than 40% at 95% MDD (Heavy Compaction).

1003.3 Crushing, Screening and Mixing

Unless otherwise instructed, crushing shall be carried out 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 of the material, including land acquisition.
- (b) The material shall be non-plastic, hard, sharp and durable as specified. The particles shall be free from organic materials, clays and other deleterious substances.
- (c) Only material passing the 6.3mm 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 ratios as well as other physical requirements as specified in Table 10.2.

Wet mix crushed stone base shall be prepared by an approved method, and shall be mixed to require moisture content prior to loading and transporting to site.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part - 8) after replacing the aggregate fraction retained on 20 mm sieve with material of 4.75 mm to 20 mm size. While adding water, due allowance should be made for evaporation losses, However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

1003.4 Construction Operations

(a) **Preparation of Sub-layer**

The surface of the subgrade/sub-base to receive the wet mix crushed stone base course shall be prepared to the specified lines and cross fall and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water. Any sub-base/base/surface irregularities where predominant, shall be made good by providing appropriate type of profile corrective course (levelling course).

(b) Provision of Lateral Confinement of Aggregates

While constructing wet mix crushed stone base arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in the subsequent sections that follow.

(c) Transportation of Wet Mix

Wet mix crushed stone base materials shall be transported and dumped in such a way that no segregation occurs.

(d) Compaction Trials

The Contractor shall carry out compaction trials in accordance with Clause 904.

(e) Laying of Wet Mix

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 Drawings or instructed by the Engineer. Every reasonable effort shall be made to prevent segregation during transportation, dumping, spreading, trimming and compacting operations. In no case should the mix be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The wet mix may be spread either by a paver or a motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

The paver shall be self-propelled, having the following features:

- Loading hoppers and suitable distribution mechanism
- Screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.
- Paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

(f) Compaction of Wet Mix

After the mix has been laid to the required thickness, grade and cross fall/camber the same shall be uniformly compacted, to the full depth with suitable roller.

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 compacted layer thickness shall be 75 mm.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the central line of the road uniformly overlapping each of the preceding tracks by at least one-third width until the entire surface has been rolled. Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls, or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the subgrade is soft or yielding or when it causes a wave like motion in the sub-base/base course or subgrade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and cross fall. In no case should the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density (heavy compaction) for the material as determined by the method as per IS 2720 Part 8.

After completion, the surface of any finished layer shall be well closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

1003.5 Proof Rolling

Unless otherwise directed by the Engineer, the Contractor shall proof roll 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 proof roller. Approval of the layer shall only be given after the satisfactory completion of the proof rolling and any remedial measures shall be at the Contractor's expense.

1003.6 Setting Out and Tolerances

Wet mix crushed stone base course shall be set out and constructed to the tolerances given in Section 700.

1003.7 Rectification of Surface Irregularity

Where the surface irregularity of the wet mix crushed stone base course exceeds the permissible tolerances or where the course is otherwise defective due to subgrade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added wet mix material or removed and replaced with fresh wet mix material as applicable and re-compacted in accordance with this specification. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with material or fines that are not approved.

1003.8 Testing

(a) Process Control

The minimum testing frequency for process control shall be as given in Table 10.3 and Section 300.

However, the frequency of tests to be conducted will be as directed by the Engineer.

Table 10.3: Minimum Testing Frequency

Tests	One test in every	Min. no of tests per section
Materials:		
Gradation	200 m ³ or part of it and change in source	2
Flakiness Index	" " " "	2
Los Angeles Abrasion	" " " "	Section 300
Aggregate Impact Value	" " " "	"
Crushing Ratio	" " " "	"
California Bearing Ratio	" " " "	"
Sodium Sulphate	500 m ³ or part of it and change in source	"
Soundness	" " " "	2
MDD, OMC	" " " "	"
Field Density	1000 m ³ or part of it and change in source 500 m ² of each layer	"
Construction Tolerances:		
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.

1003.9 Measurement

Wet mix crushed stone base course 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.

1003.10 Payment

Wet mix crushed stone base course construction shall be paid at their respective contract unit rate for all the operations, materials, labor and machineries involved and any incidental costs. In addition to the stipulation in Clause 116, 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 the TS.

1102 SHOULDERS

(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 sub base material in accordance with Clauses 1101 and 900.
- (b) Wet mix crushed stone material in accordance with Clause 1003.
- (c) Surface of the shoulder may be sealed with bituminous course in accordance with Clause 1204.

(3) Construction of Shoulders

Shoulders shall be constructed concurrently with construction of the adjacent pavement layers and with the same materials, except in case the base course is a 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 from draining off the pavement layers. The method of laying and compacting shoulder material and the compaction requirements shall be in accordance with the relevant Clauses of Section 900 and Section 1000 of the Technical Specifications.

(4) Setting out and Tolerances

Shoulders shall be set out and constructed to the tolerances given in Section 700.

(5) Surface Treatment of Shoulders

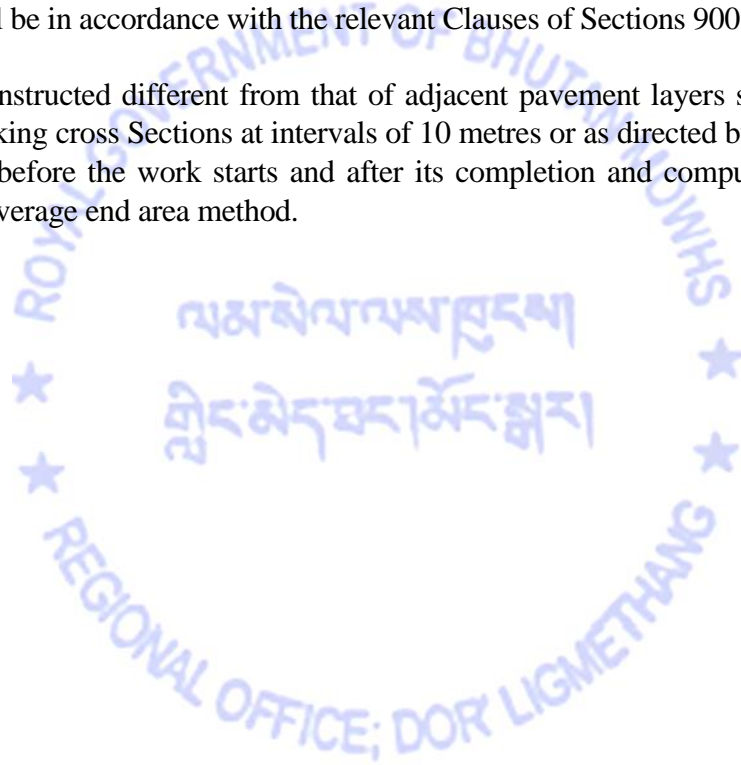
Surface treatment of shoulders shall be as shown on the Drawing or instructed by the Engineer. Materials for bituminous surface treatment shall be in accordance with Section 1203 and the method of construction shall be in accordance with the relevant Clauses of Section 1200.

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 1900 and kept watered until growth is established. Top soiling and grassing shall be in accordance with relevant Clauses of Section 1900.

(6) Measurement and Payment

Where shoulders are constructed with the same material as the adjacent pavement layers and no separate items are included in the Bill of Quantities for shoulder construction, the measurement and payment shall be in accordance with the relevant Clauses of Sections 900 and Section 1000.

Hard shoulder constructed different from that of adjacent pavement layers 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.



SECTION 1200 - BITUMINOUS SURFACE

1201 GENERAL REQUIREMENTS FOR PRIME COAT AND TACK COAT, BITUMINOUS WEARING/BINDER COURSE

1202 PRIME AND TACK COAT

1203 GENERAL REQUIREMENTS FOR ASPHALT CONCRETE

1204 ASPHALT CONCRETE

SECTION 1200 - BITUMINOUS SURFACE

1201 GENERAL REQUIREMENTS FOR PRIME COAT AND TACK COAT, BITUMINOUS WEARING/BINDER COURSE

(1) Scope

This Clause comprises general requirements for bituminous wearing/binder course, aggregate and trial sections common to Clauses from 1201 to 1204.

(2) Bituminous Binder

All bituminous binders shall comply with the relevant requirements set out in Section 200.

(3) Storage and Handling of Bituminous Binder

When carried in bulk containers, records 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 pumping ability. Any bituminous binder not conforming to the requirements of Sub-clause 1201 (4) shall be rejected by the Engineer as unsuitable for use.

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 3⁰ 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 flushing from boilers and distributors shall not be poured anywhere indiscriminately, but shall be led by drainage channels to disposal pits. Care shall be taken that flushing 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 pits and drainage channels shall be filled in and top soiled. 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 bitumen and emulsions are given in Table 12.1 below.

Table 12.1: Temperatures Ranges for Heating and Spraying Binders

Binder	Temperatures (°C)			
	Minimum Pumping	Spraying *		Maximum Heating
		Slot-jets	Atomising jets	
Cut-back RC 800	60	110 - 115	-	120
RC 3000	80	125 - 135	-	135
Cut-back MC 30	10	35 - 45	50 - 60	65
“ MC 70	25	55 - 65	70 - 85	85
“ MC 800	60	100 - 115	120 - 135	135
“ MC 3000	80	125 - 135	135 - 150	150
Bitumen 80/100	115	160 - 170	160 - 170	170

* These spraying temperatures are for guidance only, since the optimum spraying temperature depends on the temperature/viscosity relationship of the bitumen.

No penetration grade bitumen, cut-back bitumen shall be heated above the maximum temperature given in above table. Any overheated bitumen; cutback bitumen shall be removed from the site and disposed off by the Contractor.

For the rates of application of binder unless instructed by the Engineer, refer to volumes of binder corrected to 15.6°C using the 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 ⁰ C
MC-3000 cutback bitumen:	22 ⁰ C
MC-800 cutback bitumen:	15 ⁰ C
MC-30 cutback bitumen:	10 ⁰ C
Emulsions:	5 ⁰ C

Temperature of road surface shall be generally in the range of 50-60°C when prime coat is applied with MC70.

When a cold wind is blowing the above temperatures shall be increased by 5⁰ 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 12.2 may be added with the permission of the Engineer to the basic 80/100 penetration grade bitumen depending 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. Kerosene shall be used for cutting back of bitumen as per the direction of the Engineer.

Table 12.2: Maximum Addition of Paraffin

Range of Road Surface Temperature ⁰ C	Maximum Addition of Paraffin by Volume %	Range (approximate) of Corresponding Ambient Air Temperature ⁰ C
22 - 29	7	10 - 16
29 - 36	5	16 - 21
36 - 43	3	21 - 26
43 - 50	1	26 - 31
above 50	NIL	above 31

The temperature of bitumen, when paraffin (kerosene) is introduced, shall not be higher than 120⁰ 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. As a guide the adhesion agent shall be amine based anti-stripping agent and the application rate shall be 1% by weight.

(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 clothing, foot wears and gloves should be used when handling bitumen; and

(d) dust is reduced to the minimum.

Care should be taken 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 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 Sections, the Contractor shall receive permission to commence the works. No variation in the approved procedures shall be made without the Engineer's prior consent in writing.

None of the foregoing provisions shall prevent the Engineer from instructing 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-clauses from 1201 (1) to 1201 (9). The Contractor shall include related costs of complying with the requirements of Clause 1201 in his rates of the items covered in Clauses from 1202 to 1204.

1202 PRIME COAT AND TACK COAT

(1) Scope and Definitions

This Clause covers the application of a bitumen prime coat 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 blinding material.

A tack coat means a thin layer of bituminous binder applied to a bituminous surface.

(2) Materials

The prime coat shall consist 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 trails.

However, the nominal rate of application of the prime coat shall be around 0.9 litres 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 150mm. Tentative temperature of application shall be around 50°-70° C.

Primer sealer shall consist of nominal 6 mm down chips/dust mixed with cut back bitumen MC30/MC70 complying with Section 600 from a source approved by the Engineer. The application rate of chips/dust shall be 250 sqm/cum.

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). The binder shall comply with Section 200.

Blinding material shall consist of fine aggregate, or sand, or crusher dust as required and shall contain not more than 15 per cent retained on a 6.3 mm sieve. The blinding material, if required by the Engineer, shall be specified.

The choice of a bituminous primer shall depend upon the porosity characteristics of the surface to be primed as classified in IRC: 16. These are:

- i. Surfaces of low porosity, such as wet mix crushed stone base
- ii. Surfaces of medium porosity, such as cement stabilised soil base.
- iii. Surfaces of high porosity, such as gravel base.

The different ranges of viscosity requirements for the primers to be used for the different types of surfaces to be primed, as classified in 1202(2) are given in Table 12.3.

Table 12.3: Viscosity Requirement and Quantity of Bituminous Primer

Type of surface	Kinematics Viscosity of Primer at 60°C (Centistokes)	Quantity per 10 sq.m. (kg)
Low porosity	30-60	6 to 9
Medium porosity	70-140	9 to 12
High porosity	250-500	12 to 15

The bituminous primer shall be Medium Curing Cutback (MC) produced by fluxing, in an approved manner, bitumen of 80/100 penetration grade with kerosene. The cutback shall be free from water and shall not show any signs of separation prior to use.

Slow setting cationic emulsion as per IS: 8887 may also be used, but the particular grade to be used for the work shall be approved by the Engineer.

Sampling and testing of bituminous primer shall be as per Section 200.

(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 obtained 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 lightly 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 1202 (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 coat 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. If 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 12.4.

Table 12.4: Temperature for Storage

Type of Prime	Maximum storage temperature °C	
	Up to 24 hrs.	Over 24 hrs.
Cutback bitumen		
MC-30	65	40
MC-70	80	50

Bitumen shall be sprayed from a pressure distributor complying with the requirements of Sub-clause 1203 (7) and no hand spraying shall be permitted except in small areas, or to make good a defective area caused by a blocked nozzle.

The nozzles 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 sprayer, and the machine repaired before further spraying is commenced.

When commencing and stopping spraying, sheets of building paper or metal at least 2m wide shall 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 the application of the prime coat, the bituminous material fails to penetrate within the time specified or 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 $\pm 5\%$ of the rate ordered and the actual rate 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.

If, after the application of the prime coat, the bituminous material fails to penetrate within the time specified or 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.

(7) Testing

Tray tests shall be taken at least twice a day during priming operation.

The minimum testing frequency for the purpose of process control shall be as given in the Table 12.5.

Table 12.5: Minimum Testing Frequencies

Test	Minimum number of tests
Quality of binder	The Contractor shall produce certificates from concerned suppliers to the effect that all materials supplied by them comply with the relevant Specifications.
Binder temperature for application	In addition, one set of tests for each 100,000 litres of supply of binder
Rate of application of binder	At regular close intervals one test per 100 metres length of run

(8) Measurement

The quantity of prime coat or tack coat applied/sprayed shall be measured in sq.m of the total area applied.

(9) Payment

Tack coat and prime coat 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 1201 and 1202 and traffic management according to Clause 105 in addition to those specified in Clause 116.

1202.5 GENERAL REQUIREMENTS FOR DBM

Dense Bituminous Macadam (DBM)

- *Providing and Laying Dense Bituminous Macadam (DBM) to required degree of compaction based on mixture design (Job Mix Formula) approved by the supervising engineer including preparation of surface with road broom, application of prime coat @ 0.75kg/sq.m by mechanized method using asphalt plant, paver, steel roller, tyre roller etc complete.*

RW0134 75 mm

Scope: This clause specifies the construction of dense graded bituminous macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. DBM is also intended for use as a road base material. This work shall consist of construction in a single or

multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50mm to 100 mm

Materials

Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with IS: 73.

Coarse Aggregates: The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, and durable, of cubicle shape, free from dust and soft or friable matter, organic or other deleterious substances. Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Table 21.8: Physical requirements for coarse aggregate for DBM

Property	Test	Specifications
Cleanliness(dust)	Grain size analysis	Max 5% passing 0.075 mm sieve
Particle Shape	Flakiness and Elongation index (combined)	Max 30%
Strength	Los Angeles Abrasion Value	Max 35%
	Aggregate Impact Value	Max 27%
Durability(Soundness)	Sodium Sulphate	Max 12%
	Magnesium Sulphate	Max 18%
Water Absorption	Water absorption	Max 2%
Stripping	Coating and Stripping of bitumen aggregate mixtures	Minimum retained coating 95%
Water Sensitivity	Retained tensile strength	Min 80%

* The tests shall be carried out in accordance with the respective IS Specifications

Fine Aggregates: Fine aggregates shall consist of crushed or naturally occurring mineral material or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (part 37). The plasticity index of the fraction passing the 0.425mm sieve shall not exceed 4 when tested in accordance with IS: 2720 (part 5). The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4 when tested in accordance with IS: 2720 (part 5).

Filler: Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the engineer. The filler shall be graded within the limits specified below

Table 21.9: Grading of filler material

IS Sieve (mm)	Cumulative % by weight of total aggregate?
0.6	100
0.3	95-100
0.75	85 – 100

The filler shall be free from organic impurities and have a plasticity index not greater than 4. The plasticity requirement shall not apply if the filler is cement or lime. When the coarse aggregate is gravel, 2% by weight of the total aggregate, shall be Portland cement or hydrated

lime and the % of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in table A, then 2% by total weight of aggregate, of hydrated lime shall be added without additional cost.

Aggregate Grading and Binder content: when tested in accordance with IS:2386 (part 1) – wet sieving method, the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in the table B below, for DBM grading 1 or 2 as specified in the contract. The type and quantity of bitumen, and appropriate thickness, are also indicated for each mixture type.

Table 21.10: Composition of DBM pavement layers

Grading	1	2
Nominal Aggregate Size	40 mm	25 mm
Layer Thickness	80 – 100 mm	50 – 75 mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate	
45	100	
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
122.6	55 – 75	56 – 80
9.5	-	-
4.75	38 – 54	38 – 54
2.36	28 – 42	28- 42
1.18	-	-
0.6	-	-
0.3	7 – 21	7 – 21
0.15	-	-
0.075	2- 8	2 – 8
Bitumen content % by mass of total mix ²	Min 4.0	Min 4.5
Bitumen grade	65 or 90	65 Or 90

Notes:

1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.
2. Determined by the marshall method

Mixture Design

Requirement for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 22.11

Table 21.11: Requirements for dense graded bituminous macadam

Minimum stability (KN at 60°C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3-6
Percent voids in mineral aggregate (VMA)	See Table: 1.5 below.
Percent voids filled with bitumen (VFB)	65-75

The requirements for minimum percent voids in mineral aggregate (VMA) are set out in Table 22.12.

Table 21.12: Minimum percent voids in mineral aggregate (VMA)

Nominal Maximum particle Size (mm)	Minimum VMA, percent related to Design Air Voids, percent.		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

- Notes:**
1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 percent
 2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

Binder Content:

The binder content shall be optimized to achieve the requirements set out in table 1.4 and the traffic volume set out in the contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the engineer.

Where the 40mm DBM mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures; particularly the minimum stability values in table 1.4 shall be multiplied by 2.25 and the minimum flow shall be 3mm.

Job mix formula:

The contractor shall inform the engineer in writing, at least 20 days before the start of the work, of the job mix formula proposed for use in the works. While establishing the job mix formula, the contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these specifications.

Approval of the job mix formula shall be based on the independent testing by the engineer for which samples of all ingredients of the mix shall be furnished by the contractor as required by the engineer.

The approved job-mix formula shall remain effective unless and until a revised job mix formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded to the engineer for approval before placing of the material.

Plant trials – permissible variation in job mix formula:

Once the laboratory job mix formula is approved, the contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in the Table 22.13. These variations are intended to apply to individual specimens taken for quality control tests in accordance with section 900.

Table 21.13: Permissible variations from the job mix formula

Description	Permissible variation	
	Base/Binder course	Wearing course
Aggregate passing 19 mm sieve or larger	± 8%	± 7%
	± 7%	± 6%
Aggregates passing 122.6 mm, 9.5 mm	± 6%	± 5%
Aggregate passing 4.75 mm	± 5%	± 4%
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	± 4%	± 3%
Aggregate passing 0.3 mm, 0.15 mm	± 2%	± 1.5%
Aggregate passing 0.075 mm	± 0.3%	± 0.3%
Binder content	± 10°c	± 10°c
Mixing temperature		

Once the plant trials have demonstrated the capacity of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

Table 21.14: Manufacturing and rolling temperatures

Bitumen penetration	Bitumen mixing (° C)	Aggregate mixing (° C)	Mixed Material(° C)	Rolling (° C)	Laying (° C)
35	160 – 170	160 – 175	170 Max.	100 Min.	130 Min.
65	150 – 165	150 – 170	165 Max.	90 Min.	125 Min.
90	140 – 160	140 – 165	155 Max.	80 Min.	115 Min.

Laying Trials

suitable area which is not to form part of the works, unless specifically approved in writing, by the Engineer. The area of the laying trials shall be a minimum of 100 sq.m. of construction similar to that of the project road, and shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the proposed laying plant,

compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

Constructions Operations

The methodology and plant to be used for the whole project should be based arrived after plant and laying trials for the job mix ratio, which should be based on a correct and truly representative sample of the materials that will actually be used in the work, and that its different ingredients satisfy the physical and strength requirements of these specifications.

Weather and Seasonal Limitations: Laying shall be suspended while free standing water is present on the surface to be covered, or during rain, fog and dust storms. After rain, the bituminous surface, prime or tack coat shall be blown off with high pressure air jet to remove excess moisture, or the surface left to dry before laying shall start. Laying of bituminous mixture shall not be carried out when the air temperature at the surface on which it is laid is below 10degC, or when the wind speed at any temperature exceeds 40 km/h at 2m height unless specifically approved by the engineer.

Preparation of Base, prime coat and tack coat: The base on which the dense Graded bituminous material is to be laid shall be thoroughly swept clean by a mechanical broom and the dust removed by compressed air. In locations where mechanical broom cannot access, other approved methods shall be used as directed by the engineer. The prime coat and tack coat as per requirements shall be applied in accordance with their respective specifications, or as directed by the engineer.

Mixing and Transportation of the mixture: The premixed bituminous material for DBM shall be prepared in a hot-mix plant of adequate capacity and capability of yielding a mix of proper and uniform quality with thoroughly coated aggregates at appropriate mixing temperatures; the difference in temperature between the binder and the aggregate at no time should exceed 14 deg C. The hot mix plant should be calibrated from time to time in order to ensure the uniform quality of the mix and better coating of aggregates.

The bituminous material should be transported in clean insulated vehicles, and unless otherwise agreed by the engineer, shall be covered while in transit or waiting tipping. Subject to the approval of the Engineer, a thin coating of diesel or lubricating oil may be applied to the interior of the vehicle to prevent sticking and to facilitate the discharge of the material.

Spreading: Except in areas where a mechanical paver cannot access, bituminous materials shall be spread, leveled and tamped by an approved self-propelled paving machine. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously. The travel rate of the paver, and its method of operations, shall be adjusted to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space where a mechanical paver cannot be used, the material shall be spread, raked and leveled with suitable hand tools by experienced staff, and compacted to the satisfaction of the engineer. The maximum thickness of material laid in each paver pass shall be 150 mm. When laying binder course or wearing course approaching an expansion joint of a structure, machine laying shall stop short 300 mm short of the joint. The remainder of the pavement up to the joint, and the corresponding area beyond it, shall be laid by hand, and the joint or the joint cavity shall be kept clear of surfacing material.

Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a binder course is to be sealed or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated the contractor shall make it good to the satisfaction of the engineer. Binder course shall not remain uncovered by either the wearing course or surface treatment, whichever is specified in the contract, for more than three consecutive days after being laid. The Engineer may extend the period by minimum amount of time necessary, because of weather conditions or for any other reason.

Rolling: Bituminous materials shall be laid and compacted in layers which enable the specified thickness, surface level, regularity requirements and compaction to be achieved. Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperature (?). Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the centre longitudinally except that on super-elevated and uni-directional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8-10 tonnes dead weight smooth wheeled rollers. The intermediate rolling shall be done with 8 – 10 tonnes dead weight or vibratory roller or with a pneumatic tyred roller of 12 to 15 tonnes weight having nine wheels, with a tyre pressure of at least 5.6 kg/sq.cm. The finish rolling shall be done with 6 to 8 tonnes smooth wheeled tandem rollers. Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third of the width of the rear roll or, in the case of a pneumatic-tyred roller, at least the nominal width of 300 mm. Rollers shall move at a speed of not more than 5km/h. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign material on the pavement either when the rollers are operating or standing. The wheels of the rollers shall be kept moist with water, and the spray system provided with the machine shall be in good working order, to prevent the mixture from adhering to the wheels. Only sufficient moisture to prevent adhesion between the wheels of the rollers and the mixture should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

Where longitudinal joints are made, the materials shall be fully compacted and the joint made flush. All joints shall be offset by at least 300 mm from parallel joints in the layer beneath or as directed, and in a layout approved by the engineer. Joints in the wearing course shall coincide with either the lane edge or the lane marking, whichever is appropriate.

Opening to traffic: The newly laid surface shall not be open to traffic for at least 24 hrs after laying and completion of compaction, without the express approval of the Engineer in writing.

Measurement: The finished work shall be measured in sq.m at a specified thickness correct to two places of decimal.

Rate: The rate shall include the cost of materials and labour required to carry out all the operations.

1203 GENERAL REQUIREMENTS FOR ASPHALT CONCRETE

(1) Scope

This Clause comprises all the general requirements for bituminous mixes which shall apply to Clause 1203.

(2) Construction Plant

(a) General

The Contractor shall submit to the Engineer full details of the construction plant the Contractor proposes to use and the procedures the Contractor proposes to adopt for carrying out the pavement works.

The Engineer shall have access at all times to construction plant for the purposes 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 and 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.

Sufficient and separate storage space shall be provided for each size and type of aggregate. Different aggregates sizes shall remain separated until they are delivered to the cold elevator feeding the drier. The storage yard shall be neat, orderly, and stockpiles readily accessible for sampling by the Engineer.

The plant may be either batch-mix type or the continuous-mix type and shall be capable of regulating the composition of the mixture within the tolerances specified in Sub-clause 1203 (14). The plant shall include truck scales and a recorder.

The bitumen tank shall be capable of maintaining its contents at the specified temperature within a tolerance of $\pm 5^{\circ}\text{C}$ and shall be equipped with a thermostat to prevent the temperature rising above 180°C and a fixed thermometer easily readable from outside the tank. Any bitumen which has been heated above 180°C or has suffered carbonisation from prolonged heating shall be removed from the plant and disposed off.

The Engineer or his authorized representative shall have access at all times to all parts of the plant for checking adequacy of equipment; inspecting operation of the plant, verifying weights, proportions and character of materials; and checking the temperatures maintained in the preparation of the mixtures.

(c) Hauling Equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds. To prevent the mixture from adhering to them, the beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather, and an insulated bed to maintain the mixture at the specified temperature.

(c) Laying Plant

Bituminous materials shall be laid by a self propelled paver capable of laying bituminous materials with no segregation, dragging, burning or other defects and within the specified width, level and surface regularity tolerances. It shall be equipped with a receiving hopper of sufficient capacity to permit uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike off assembly shall effectively produce a finished surface of the required evenness and texture, without tearing, shoving, or gouging the mixture. The paver shall be capable of operating at forward speeds consistent with satisfactory paving of the mixture.

(d) Compaction Plant

The Contractor shall provide sufficient rollers of adequate size and weight sufficient to compact the mixture to the required density while the mixture is still in workable condition. Rollers shall be capable of reversing without backlash, and operating at slow speeds to avoid displacement of the asphalt concrete mixture. The use of equipment which results in excessive crushing of the aggregate shall not be permitted. Prior to commencing the laying of bituminous mixes in the pavement works the Contractor shall carry out site trials in accordance with Section 300 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 tack coat shall be applied prior to laying the bituminous mix or between layers of the bituminous mix, in accordance with Clauses 1201 and 1202. In case asphalt concrete is to be provided on new pavement as wearing course or binder course, prime coat shall be applied in accordance with Clauses 1201 and 1202.

(4) Job Mix Formula

The Contractor shall produce aggregates meeting the grading requirements of the Specification.

No work shall be started on the project nor any mixture accepted until the Contractor has submitted samples of the materials intended for use and the Engineer has approved a satisfactory job mix formula for each required material grading.

At least one month prior to commencing work using a bituminous mix, the Contractor shall 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 unless otherwise specified or directed by the Engineer.

The Contractor shall then carry out laboratory tests in order to propose the proportions of each constituent of the initial mix or mixes to be used for site trials to be carried out in accordance with Sub-clause 1025 (5). The Contractor shall submit his proposed job mix formula to the Engineer for approval, together with copies of all supporting laboratory test data to show that the mix complies in all respects with the requirements of this Specification.

Should the Engineer conclude from the site trials that the mix proportions or aggregate grading 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 to produce an acceptable job mix formula.

The Engineer may instruct the alteration of the composition of the aggregates passing through 0.075 mm by the addition or substitution of mineral filler.

The Contractor shall make the necessary adjustments to his plant to enable the revised mix to be produced.

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 1203 (14).

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 any new mix design subsequent to that.

(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 constructing 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 the completed asphalt pavement layer can be achieved.

Each trial area shall be at least 100 metres long and 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 program 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 permanent work on that layer.

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

- (a) The composition and grading of the material including the bitumen content and type and grade of bitumen used.
- (b) The moisture content of aggregate in the asphalt plant hot bins.
- (c) 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 are to be measured in accordance with BS 598, Part 109.
- (d) 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.
- (e) The target voids and other target properties of the mix together with the results of the laboratory tests on the mix.
- (f) The density and voids 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 of trial for each level of compaction effort and provided all eight sets of results over the range of compaction 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) Preparation of Mineral Aggregate

The aggregate for the mixture shall be dried and heated in the plant before entering the mixer. When introduced into the mixer, the combined aggregate shall contain not more than 0.5% moisture. Water in the aggregate shall be removed by heating to the extent that there is no subsequent foaming in the mixture prior to the placing of the material. The aggregate shall be heated to the temperature designated by the job mix formula within the job tolerance specified. The maximum temperature and rate of heating shall be such that no damage occurs to the

aggregates. Particular care shall be taken that aggregate high in calcium or magnesium content is not damaged by overheating. The aggregates shall be dried and heated so that they are mixed at the temperatures 125° - 165°C when 80/100 bitumen is used, unless otherwise specified in Clause 1204.

(7) Mixing of Aggregates and Bitumen

The bitumen shall be heated so that it can be distributed uniformly. Care shall be taken not to overheat it. The temperature should never exceed 170°C for 80/100 bitumen.

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 quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer. In case of volumetric proportioning, the size of the gate opening shall be determined, and the gates locked in position.

The quantity of bituminous material for each batch or calibrated amount for continuous mixer shall be determined by the Engineer. It shall be measured by weight and introduced into the mixer at the specified temperature, using the lowest range possible for adequate mixing and spreading. For batch mixing, all mineral aggregates shall be in the mixer before the bituminous material is added. The exact temperature within the specified range shall be fixed by the Engineer. In no case shall aggregates be introduced into the mixture at a temperature more than 11 ° C above the temperature of the bituminous material.

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 obtaining a uniform mix and thorough coating.

This time is dependent upon the mix design and the type of mixing equipment used. To compute the mixing time in a continuous mixer, the weight of its contents at operating level is divided by the weight of the mixture delivered per second by the mixer.

$$\text{Mixing time in Seconds} = \frac{\text{Pugmill dead capacity in kilograms}}{\text{Output in Kilograms per Second}}$$

(8) Transportation of the Mixture

The asphalt concrete mixture shall be transported from the mixing plant to the point of use in vehicles described in Sub-Clause 1203(2) of this specification. 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.

(9) 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 placed at a temperature between 126 °C and 150 °C. When the mixture is being placed during warm weather and the Engineer has determined that satisfactory results can be obtained at lower temperatures, he may direct that the mixture be delivered at a temperature within the tolerance allowed in the approved job mix formula.

The mixture shall be placed in widths of one traffic lane at a time, unless otherwise agreed by the Engineer. The compacted thickness of any layer shall be as shown on Drawings or directed by the Engineer. The compacted thickness of any 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 areas where irregularities or unavoidable obstacles make the use of mechanical laying impracticable, the mixture may be spread and compacted by hand using equipment approved by the Engineer.

The bituminous mixture shall not be placed during rainfall, foggy and cold weather, when the air temperature in the shade is 10 °C or lower, unless so directed by the Engineer. The Engineer may permit work to continue when overtaken by sudden rains only to provide for laying the material which is in transit from the plant, provided the mixture is in transit from the plant, and provided the mixture is within the temperature limits specified.

(10) 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 the 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 or 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 centreline, each trip overlapping one half of the roller width. On super elevated 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 plate compactor or a hand tamper shall be used to achieve the specified compaction.

(11) Finishing, Joints 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 to 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 and have an approximately vertical face. The mixture placed in the abutting lane shall then 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.

(12) Sampling of Bituminous Mixtures

The sampling of bituminous mixtures shall be carried out in accordance with ASTM Designation D979.

(13) Quality Control 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 200 and relevant Clauses of Section 1200.

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 own expense.

(14) Tolerances

Surfacing and base shall be constructed within the geometric tolerances specified in Section 700.

The Contractor shall maintain the composition of the mixture as determined from the laboratory and site trials within the following tolerances, per single test:

- (a) Bitumen content : $\pm 0.3\%$ of (Total weight of bitumen in total mix)

(b) Aggregates

- (i) Passing through 10 mm sieve and larger sieves: $\pm 6\%$ of (Total weight of dry aggregate)
- (ii) Passing through 10 mm sieve and retained on 1mm sieve: $\pm 4\%$ of (Total weight of dry aggregate)
- (iii) Passing through 1 mm sieve and retained on 0.075 mm sieve: $\pm 3\%$ of (Total weight of dry aggregate including mineral)
- (iv) Passing through 0.075 mm sieve : $\pm 2\%$ of filler

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 from the check weights of mix shall not vary beyond the limit 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 centreline 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.

(15) Measurement and payment

No separate measurement and payment shall be made for complying with the requirements of the Clause 1203. The Contractor shall allow compensation for compliance of the Clause 1203 in the rates of items covered by Clause 1204.

1204 ASPHALT CONCRETE

(1) Scope

This Clause covers the materials, method of construction and requirements for the construction of asphalt concrete. The asphalt concrete shall be composed of mineral aggregate and bituminous material, mixed in a central hot mix plant and placed on a prepared course in accordance with these Specifications and shall conform to the dimensions and typical cross section shown on the Drawings and with the lines, levels and grades instructed by the Engineer. The asphalt concrete shall be used for pavement overlay courses, laid in single layer or more than one layer comprising wearing and binder courses.

As specified on the Drawing or as directed by the Engineer, each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished and approved before the placement of the next course.

(2) Definition

Asphalt concrete means a thoroughly controlled, hot-mixed, hot-laid, plant mixture of well graded dried aggregate and penetration grade bitumen, which, when compacted, forms a dense material.

(3) Materials

(a) Penetration Grade Bitumen

Bitumen shall be 80/100 penetration grade as specified in Section 200.

(b) Aggregate

The aggregate shall consist of crushed stone, or crushed gravel, with or without sand or other inert finely divided mineral aggregate. The aggregate shall be clean; composed of sound, tough, durable stone/rock particles; free from weathered or decomposed stone, shale, clay, silt, organic matter, and other deleterious substances. The coarse aggregate shall be entirely crushed.

The coarse aggregate shall comply with the requirements given in the Table 12.6.

Table 12.6: Physical Properties for Coarse Aggregates for Asphalt Concrete

Property	Test	Specification
Particle shape Strength*	Flakiness and Elongation Index	Maximum 25%
	Los Angeles Abrasion Value	Maximum 30%
Durability	Aggregate Crushing Value	Maximum 25%
Water Absorption	Sodium Sulphate Soundness	Maximum 12%
Stripping	Water Absorption	Maximum 2%
	Bitumen Stripping	Minimum retained coating 95%

* Aggregate may satisfy requirements of either of these two tests unless otherwise agreed by the Engineer.

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 percent. The Sand Equivalent of the fine aggregate shall not be less than 60 and the Sodium Sulphate Soundness of not more than 12 percent.

(c) Mineral Filler

If additional filler is necessary, it shall consist of stone dust, Portland cement, or other approved mineral matter. The filler material shall meet the requirements of Clause 8 of BS 594. It shall be thoroughly dry and free from lumps. At least 75% (by weight) shall pass a 0.075mm sieve and 100% shall pass a 0.425mm 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 12.7 or as specified in the Bill of Quantities.

Table 12.7: Gradation Requirements of Aggregate for Asphalt Concrete

Sieve Size (mm)	Percent Passing by weight		
	Type I Aggregate size 25 mm max.	Type II Aggregate size 19 mm max.	Type III Aggregate size 12.5 mm max.
25.0	100		
19.0	80-90	100	
12.5	70-90	80-100	100
9.5	60-82	68-90	80-100
4.75	42-70	50-79	60-90
2.0	30-60	36-67	40-60
0.425	15-40	17-44	25-40
0.180	8-26	9-29	10-30
0.075	3-8	3-8	3-8
Bitumen Content ¹	6.0-7.5	5.0-6.0	5.0-7.5

¹ percent by mass of total mix as determined by the Marshall method

The aggregate shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa. Selection of gradation shall be such that the maximum size aggregate used shall not be more than one - half the thickness of the layer of the bituminous course being constructed.

The bitumen content of the working mix shall be instructed by the Engineer following laboratory and site trials.

(5) Requirements for Asphalt Concrete

Asphalt concrete i.e. the mixture of binder, coarse and fine aggregates and mineral filler, if any, shall comply with the requirements given in the Table 12.8.

Table 12.8: Requirements for Asphalt Concrete

Asphalt Concrete	Wearing Course	Binder Course, Regulating/Levelling Course
Marshall Stability (75 blows/face, N)	Min 8000	Min 6000
Flow Value (mm)	2 - 6	2 - 6
Voids in total Mix (%)	2 - 6	3 - 7
Compression/Immersion Ratio ²	>0.75	>0.75

² as per ASTM D1075

(6) Construction Operations

The laying and compaction of asphalt concrete mixture shall be as specified in Clause 1203. Grade control between the edges of the pavement shall be accomplished by grade stakes or steel pins placed in lanes parallel to the centerline of the pavement and at intervals sufficiently close that string lines may be stretched between stakes or pins.

Placing shall be in accordance with the agreed staging sequence as jointly determined by the Engineer and the Contractor. Hauling over new bituminous material already placed shall not be

permitted until the material has been thoroughly compacted as specified, then allowed to cool to atmospheric temperature.

The mixture shall be dumped into paver as specified in Clause 1203 and immediately spread to the full width required. It shall be struck off in a uniform layer of such depth that, when work is completed, it will have the thickness and will conform to the grade and surface profile required. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat.

The mixture shall be placed in strips width as may be approved by the Engineer. To ensure proper drainage, the spreading shall be along the centerline of the pavement on a crowned section or on the high side of the pavement with a one - way slope. After the first strip or width has been compacted, the second width shall be placed, finished, and compacted in the same manner as the first width. After the second strip has been placed and rolled, a 3 meter straightedge shall be placed, across the longitudinal joint to determine if the surface conforms to grade and profile requirements.

Exposed vertical edges of paved strips shall be free of all accumulations of dirt or other foreign material before any mixture is spread in an adjacent lane. If joint faces become dry or dusty, the contact surfaces should be given a brush coat of asphalt tack coat. In lieu of tacking cold contact surfaces, the Contractor may use a joint heater approved by the Engineer. If the spreading machine should drift from an adjacent lane during construction, the unfilled space shall be carefully filled with fresh hot mixture obtained from the truck or the hopper of the spreading machine. Use of mixture already spread to fill up these areas shall not be permitted.

In areas where the use of mechanical spreading and finishing equipment is deemed impractical, owing to irregularities or obstructions, bituminous premix may be hand spread. When hand spreading is permitted, the mixture shall be dumped on approved dump sheets outside of the area upon which it is to be spread, and then distributed into place immediately with hot shovels. It shall be spread with hot rakes in a uniformly loose layer to the full width required and of such depth that, when the work is completed, it will have the required thickness and will conform to the grade and surface contour shown on the plans.

After spreading, the AC mixture shall be thoroughly and uniformly compacted with power rollers, as directed by the Engineer. Rolling of the mixture shall be soon after spreading, as it will bear the roller without undue displacement or hair cracking. On the first strip spread, rolling shall start in the center and continue toward either edge. On subsequent strips laid, rolling shall start on the edge adjacent to previously laid material and continue toward the opposite edge.

Initial rolling shall be done longitudinally. The roller shall overlap on successive trips. Alternate trips of the roller shall be of slightly different lengths. The mixture shall be subjected to diagonal rolling; crossing the lines of the first after three or more lanes are constructed, but cross rolling shall not exceed more than one half the width of the pavement on crowned section.

The speed of the roller shall, at all times, be slow to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by rakes, and the addition of fresh mixture.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until all roller marks are eliminated, the surface of uniform texture and true to grade and cross section, and a density of 98 % of the maximum laboratory density of the job mix.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers.

Any mixture, which becomes loose or broken, mixed with dirt, or in any way defective shall be removed to full depth and replaced with fresh not mixture and immediately compacted to conform to the surrounding area. This work will be done at the Contractor's expenses. Skin patching shall not be allowed.

The mixture at the joints shall comply with the surface requirements and present the same uniformity of texture, density, smoothness, etc., as other sections of the course. In the formation of all joints, provision shall be made for proper bond with the adjacent course for the specified depth of the course. Joints shall be formed by saw - cutting the previously placed bituminous course to expose the full depth of the course; the exposed edge shall be given a light coat of asphalt cement or bitumen as specified by the Engineer. The fresh mixture shall be raked against the joint and thoroughly tamped and rolled.

While the surface is being compacted and finished the Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be leveled while still hot with the back of a rake or a smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

At the end of day work ramps shall be provided longitudinally and transversally on asphalt concrete paving lanes as shown on Drawings or as directed by the Engineer, to facilitate easy roll of vehicles. To start the next laying operation, the ramp shall be removed by saw - cutting to create a vertical joint face at the end of the paving lane (before the ramp was placed) and removing and disposing of ramp material to the cut line. The joint will be painted with hot bitumen before laying mixture and paving shall start from its interface.

(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 satisfying himself that the materials 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 materials from the mixing plant to the paver, but the Engineer may direct for sampling to be carried out from the paver, if there is any danger of segregation of the mix during transportation and spreading process.

The Contractor shall remove 100 mm minimum diameter core samples of the completed pavement from locations designated by the Engineers so that the composition, compaction and density of the pavement may be tested. Samples for each day or fraction thereof shall be taken at a rate of one core per 1000 m². The Contractor shall at his own expense replace the bituminous pavement in the core holes with new mixture meeting this specification. Pavement

deficient in composition, compaction, or thickness, shall be corrected by the Contractor at his own expenses to the satisfaction of the Engineer.

(b) Process Control

The minimum frequency of testing required for process control shall be as provided in the Table 12.9.

However, the frequency of tests to be conducted will be as directed by the Engineer.

Table 12.9: Minimum Testing Frequency

Test	Minimum number of tests
AGGREGATE:	
Grading	One test for every 100 m ³ or part of it and change of source
Los Angeles	" 500 m ³ " "
Aggregate Crushing Value	" " " "
Flakiness Index	" 100 m ³ " "
SSS	" 500 m ³ " "
Sand Equivalent	" " " "
Quality of Filler	" 50 tonnes " "
BITUMEN:	
Quality of Binder	<i>The Contractor shall produce certificates from all suppliers to the effect that all materials supplied by them comply with the relevant Specifications.</i> In addition, one set of tests for each 50,000 litres or part of it of supply of binder Daily
Penetration Test	
MIXTURE	
Grading and bitumen content	One test for each 100 tonnes of mix or part of it " " "
Marshall stability, flow and voids	As required
Control of Temperature	
CONSTRUCTION TOLERANCES:	
Compaction	One test per 500 m ² or part of it Every 10 m or at close intervals
Surface levels	" 50 m ² "
Smoothness	

(8) Measurement

Asphalt concrete shall be measured in area in sq.m calculated as the product of the length and the width of the asphalt concrete laid as per Drawing or as instructed by the Engineer.

(9) 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 of Clauses 1203 and 1204 and traffic management according to Clause 105 in addition to those specified in TS.

SECTION 1300 – STONE MASONRY WORK

- 1301 SCOPE
- 1302 MATERIALS
- 1303 CONSTRUCTION
- 1307 RANDOM RUBBLE - COURSED OR UNCOURSED
- 1308 DRY RANDOM RUBBLE
- 1309 COMPOSITE RANDOM RUBBLE
- 1310 STONE PITCHING
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- 1313 MEASUREMENT
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SECTION 1300 – STONE MASONRY WORK

1301 SCOPE

This Section covers furnishing of materials and construction of different types of stone masonry works in accordance with the Drawing and this Specification or as directed by the Engineer. These works will be required for retaining structures, drains and channel lining, slope and drainage protection works or other works as directed by the Engineer.

Activities involved will include supply of stones, dressed bond stone, cement, sand, water, equipment, tools & plants, preparation of mortar, placing and joining stones dry/with mortar, curing, collection and testing of specimens, etc.

1302 MATERIALS

All requirements in respect of stones and cement sand mortar described herein shall be applicable in all Clauses of this Section, if otherwise not specified.

(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, and free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. Stones for coursed or uncoursed stone rubble masonry shall have broken face on three sides. Stones for dressed rubble masonry shall have dressed face on all sides. 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 $\frac{3}{4}$ th thickness of the wall. At least 80% of the stones used in masonry, except those used for chinking as chips or spalls of stones shall have individual volumes of more than 0.01 m³. 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 shall comply with IS 2250–198.

Sand shall comply with IS 2116. Cement shall be ordinary Portland cement as per IS 8112 or IS 12269 or as directed by engineer.

Water shall be clean and free from detrimental concentration of acids, alkalis, salts, and other organic or chemical substances. If instructed by the Engineer the Contractor shall prove the suitability of the water by tests carried out by an approved laboratory. Such tests shall comply with the requirements of IS: 3029-1964.

The mixing shall be done in a mechanical mixer unless hand-mixing is permitted by the Engineer. If manual mixing is allowed, the operation shall be carried out on a clear watertight platform. The cement and sand shall be first mixed dry in the required proportion to obtain 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 manual mixing, the mortar 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.

1303 CONSTRUCTION

The method of construction described herein shall hold good in all Clauses of this Section, wherever applicable.

(1) General

Construction shall be carried out in accordance with IS : 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. Face work 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 face work. At no time shall the backing be built up higher than the face work.

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 all masonry works, a levelling course of M15/20 concrete 100mm thickness shall be laid to ensure a level and stable foundation.

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 shall be 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.

The holes left in the masonry work for supporting scaffolding shall be filled and finished with M15 grade concrete.

The masonry work in cement mortar shall be kept constantly moist for a minimum period of 7 days, unless otherwise specified.

(2) Concrete Capping

Where masonry structures are constructed 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 1600.

(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 only if shown on the Drawings and/or as directed by the Engineer. Pointing shall be carried out using cement mortar as shown on the Drawing or as directed by the Engineer. 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 : 20mm
- Coursed Rubble : 15mm
- Ashlar Masonry : 5mm

(4) Weep holes

Weep holes shall be provided in solid plain concrete/reinforced concrete, brick/stone masonry, abutment, wing wall or other structures as shown on the Drawing or as directed by the Engineer. Weep holes shall have opening of 100 mm wide, 100 mm high or circular with 100 mm diameter

1307 RANDOM RUBBLE - COURSED OR UNCOURSED

All stones shall be carefully set with bond stones running right through the thickness of walls up to 600 mm thickness and in case of walls above 600 mm thickness a set of two or more bond stones overlapping each other by minimum 150 mm shall be provided in a line from face to back. At least one bond stone or a set of bond stones shall be provided for every 0.5 m² of the wall surface. If the bond stone of sufficient length is not available then plain cement concrete (M15 grade concrete) block of cross-section not less than 200x150 mm shall be provided.

In case of highly absorbent types of stones (porous lime stone and sand stones etc) the bond stone shall extend about two third into the wall. The bond stones in such cases may give rise to damp penetrations therefore, for all thickness of such walls, a set of two or more bond stones overlapping-each other by at least 150 mm shall be provided.

For random rubble masonry, the face stones shall be hammer dressed on all beds and joints and the quoins shall be of selected stones neatly dressed with the hammer chisel to form the required angle, and laid header and stretcher alternately.

In case of coursed rubble masonry, the face stones shall be hammer dressed on all beds and joints so as to give them approximately rectangular block shape. The bed joint shall be dressed for at least 80 mm back from the face and side joints for at least 40 mm such that no portion of the dressed surface is more than 10 mm from a straight edge placed on it. The remaining portion of the stone shall not project beyond the surface of bed and side joints. The bushing on the face shall not project more than 40 mm on exposed face and 10 mm on a face to be

plastered. The face stones shall be laid alternate headers and stretchers without pinning on the face. Bond stones shall be provided as specified above except that the spacing of a bond stone or set of bond stones shall be about 1.5 m or as directed by the Engineer. The quoins shall be of same height as the course. These shall be minimum 380 mm long and laid alternate header and stretcher.

1308 DRY RANDOM RUBBLE

Dry random rubble masonry shall be constructed generally to the requirements of coursed random rubble masonry as specified in Clause 1307 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. No round stones shall be used in dry stone masonry work. The stones in courses shall be laid perpendicular to the batter face. Bond stones shall be provided at the rate of at least 10 percent of volume of dry stone masonry structure. Bond stones shall measure not less than 150 mm x 150 mm and not less than 450 mm in length or full thickness of wall, whichever is less. The exposed tops or capping of dry rubble structures shall be formed as shown on the Drawing or as directed by the Engineer.

1309 COMPOSITE RANDOM RUBBLE

Materials for composite random rubble shall comply with Clause 1302 and construction with Clause 1303. Mortar masonry shall be coursed and comply with Clause 1307 and the dry stone insets with Clause 1308. 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.

1310 STONE PITCHING

(1) General

Stone pitching work shall be required for lining of drains and channels.

(2) Material

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, and free from iron bands, spots, sand holes, flaws, shakes, cracks or other defects. The stone shall not absorb water more than 5 per cent. Stones for pitching shall not be less than 150 mm in minimum dimension. Rounded stones shall not be used in stone pitching. The mortar shall comply with Sub-Clause 1302(1).

(3) Mock-Up

Prior to commencement of any stone pitching work the Contractor shall construct a stone pitching panel of approximately 2000 mm x 1000 mm as a trial. The trial if accepted by the Engineer shall be the sample for actual work.

(4) Construction

Stone pitching shall be done on surface prepared to specified requirements. Stones shall be laid in mortar with their longitudinal axis across to the direction of flow. Thickness of mortar in bed shall be 25 to 35 mm. They shall be well set into the surface. Thickness of pitching will be as shown on Drawings or as directed by the Engineer. Spaces between stones shall be filled

with spalls. Finished surface shall present an even, tight and neat appearance with no stones varying by more than 20 mm from specified grades and lines. Joints between the stones shall be completely filled with MM 7.5 mortar. Finished surface shall present an even, tight and neat appearance with no stones varying by more than 20 mm from specified grades and lines.

1311 STONE SOLING

Stone soling are required in the construction of foundation beds for various structures as directed by the Engineer. Stones shall comply with Clause 1302 of this specification. Stone soling shall be done on foundation surface prepared as specified. They shall be well rammed into the surface. Spaces between stones shall be filled with spalls or smaller stones securely rammed into voids. The completed work shall present an even, neat and tight surface.

1312 REPAIRS/REHABILITATION OF EXISTING STRUCTURES

- (1) Dismantling and removal of existing masonry wall /PCC catch pit in cement mortar in drain, wall, culverts etc including stacking of material for reuse and disposal of waste materials shall be carried out as per drawing or as directed by the Engineer. The dismantling may be required either for scrapping of the structures, to extend or to replace the same by new structure.
- (2) Existing structures such as retaining walls shall be cleaned of vegetation, plants and trees and roots uprooted or poisoned to apply a layer of concrete shotcrete of nominal 15 mm thickness.
- (3) Drilling and installation of pipe dowels 32 mm dia. 1 m c/c shall be carried out into existing causeways including grouting as per drawing. This shall be done to construct additional wall over the existing causeways/masonry walls particularly over existing causeways on cross drainage as per drawing or as directed by engineer.
- (4) Extension of masonry wall without any cross drainage works shall be done using standard bond stones.
- (5) The face of the existing masonry wall shall be shotcreted to strengthen the wall. The rate of application shall be in agreement with the engineer after few shotcrete trial works.
- (6) The existing parapets shall be repaired wherever these are damaged or new one constructed as per the direction of the engineer.

1313 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 10 m³ 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 IS1124 and it shall not be more than 5 percent. Sand shall be tested as per

Clause 211 or as directed by the Engineer. At least 3 set of tests for stone and sand shall be conducted for every source.

1314 MEASUREMENT

Stone work shall be measured in cubic metres. No separate measurement shall be carried out for pointing, if pointing was carried out.

Weep holes shall not be measured separately. No deduction in the volume of structures shall be made for weep holes.

Repairs/rehabilitation of existing structures shall be measured as per their respective unit of measurement. Deductions shall be made for not meeting the thickness of cement grouting at the discretion of Engineer.

1315 PAYMENT

The stone masonry shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 116 to complete the work in accordance with these Specifications. The contract unit rate for respective items shall be deemed to have included costs for labor, materials, tools & plants etc including the costs for providing pointing and weep holes.

SECTION 1400 – BRICK MASONRY WORKS

1401 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.

1402 MATERIALS

(1) Bricks

Burnt clay bricks shall conform to the requirements of IS 1077 and IS 2180 and shall be of the best quality locally available as approved by Engineer. The bricks shall be free from cracks, flaws, grit and other impurities such as lime, iron and deleterious salts. All bricks shall be well burnt, sound and hard with sharp edges giving a ringing sound when struck with a mallet.

Bricks shall not show any signs of efflorescence when dry or subsequent to soaking.

The bricks shall not absorb water more than 7% of its weight after the 5 hour boiling test.

The standard brick sizes shall be 9 ¼” x 4 ¼ x 2 ¼” (230mm x 110mm x 55mm). The dimensions for sizes of bricks may be amended by the Engineer to suit the local condition.

The bricks shall have a minimum average compressive strength of 100 kg/cm² and transverse strength of 32 kg/cm². Random compressive strength testing shall be done as prescribed by the Engineer.

Where bricks are to form fair face construction, they shall be individually selected for colour, size, shape, and quality and if required shall match bricks in existing construction. Bricks shall be inspected by the Engineer who may reject any or all bricks before incorporation in the works.

Where the Engineer requires bricks to be classified by their intended use in construction, bricks of each classification shall be stored separately and apart and be clearly identified as instructed. Rejected bricks shall be immediately removed from the site.

Bricks shall not be dumped on the site. Bricks shall be carefully stacked in regular layers and otherwise handled and stored at all times so as to avoid damage.

(2) Mortar

The mortar for brickwork and plastering shall comply with Sub-Clause 1302(2) of the Technical Specifications.

1403 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.

1404 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.

The weep holes shall be provided as per Clause 1303 of the Technical Specifications.

1405 JOINTS

The thickness of joints shall not exceed 10 mm.

1406 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.

1407 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.

1408 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.

1409 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.

1410 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 Sub-Clause 1302(2).

(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 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

The grade and thickness of mortar for plastering shall be as specified on Drawing or as directed by the Engineer. Plastering shall be started from top and worked down. All 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 suitably protected from all damages.

1411 BRICK SOLING

(1) General

This Clause shall consist of the provision and placing of all materials for the construction of brick soling in foundation to the dimensions and locations shown on the Drawings or as directed by the Engineer. It shall also include preparation of surface to the specified requirements.

(2) Materials

Brick for soling shall be as described in Sub-Clause 1402(1).

(3) Construction

- (a) Foundation bed for brick soling shall be trimmed to the required level and compacted by hand or suitable mechanical equipment to a density of not less than 95% of the maximum dry density of the material as determined by the method described in IS2720-Part 8. The Contractor shall not be permitted to place the brick soling until the Engineer has tested and approved the levels and compaction of the surface.
- (b) Brick for soling shall be laid on edge or flat as shown on Drawings or as directed by the Engineer on foundation bed prepared as above. Shoulder coursing shall be provided at all edge conditions and elsewhere shown on the drawings.
- (c) After completion the brick paving shall have a true and level surface to the required slope. The finished level of the soling at any point shall be within plus or minus 10 mm of the levels shown on the Drawings or as directed by the Engineer.

1412 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 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 the 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 and shall meet the requirement of this Specification. The surface of the brick soling shall show no depression in excess of 5 mm when tested with a 3m straightedge placed anywhere on the completed surface. The Contractor shall remove and replace any work outside the tolerances stated above.

1413 MEASUREMENT

All brick work shall be measured in cubic metres. The work of plastering and pointing shall be measured in square metres separately.

1414 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 116 to complete the work as per these Specifications.

SECTION 1500 – GABION WORK

- 1501 SCOPE
- 1502 MATERIALS
- 1503 CONSTRUCTION OF GABIONS
- 1504 TEST AND STANDARD OF ACCEPTANCE
- 1505 MEASUREMENT
- 1506 PAYMENT

SECTION 1500 – GABION WORK

1501 SCOPE

This Clause covers the furnishing of materials and construction of gabion works that may be required to act as buttresses, retaining walls, catch walls, stream or river training structures, check dams within gullies, or where placed as mattresses, to prevent stream or gully erosion.

1502 MATERIALS

(1) Stones

Stones used for filling the gabion boxes or mattresses shall be clean, hard, sound, un-weathered 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 thickness. The smallest dimension of any stone shall be at least twice that of the longer 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 stones.

Before filling any gabion boxes and mattresses the Contractor shall submit representative samples of the rock he proposes to use in the gabions 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.

(2) Gabions

Gabions shall consist of steel wire mesh crates. The steel wire shall be mild steel wire complying with IS 280-197. All wires used in the manufacturing of crates and diaphragms, binding and connecting lids and boxes shall be galvanised with a heavy coating of zinc by an electrolytic or hot dip galvanising process. The weight of deposition of zinc shall be in accordance with IS 4826-1979. Zinc coating shall be uniform and be able to withstand minimum number of dips and adhesion test specified in IS 4826-1979. Tolerance on diameter of wire shall be + 2.5 percent. The tensile strength of gabion wire shall be between 300 and 550 N/mm².

All gabions shall be machine made. The wire shall be woven into a 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 15.1 with mesh and wire sizes as shown in Table 15.2.

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 15.1. All crates shall be supplied with binding and connecting wire of the gauges shown in Table 15.2 of sufficient quantity to bind all diaphragms and closing edges.

Table 15.1: Standard Size of Wire Mesh Gabions

Dimensions in metres (Prior to fill)	Number of diaphragms	Dimensions 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 0.5	-	-	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 15.2: Standard Sizes 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
(D x H)		SWG	SWG	SWG
83x114	80x100	9,10,11	11,12,13	6,7,8
114x128	100x120	10,9	12,11	7,6

The mesh opening shall be as instructed by the Engineer.

Equivalent diameter in mm

SW	6	7	8	9	10	11	12	13	14
mm	4.88	4.47	4.06	3.66	3.25	2.95	2.64	2.34	2.0

1503 CONSTRUCTION OF GABIONS

(1) 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 in accordance with the Specification.

(2) Preparation of Foundation and Surface for Bedding

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.

(3) Arrangement of Joints

(a) 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, units of unequal length shall be used and the joints between them should be staggered.

(b) 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, units 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.

(c) 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 15.2, 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 poked 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 250mm 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.

(d) Filling

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 gabions before filling. The vertical corners shall be kept square and to full dimension by

inserting a steel bar 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 selvages of the crate shall be bound to the selvages of adjacent crates with binding wire. Where crates are being assembled in position in a wall the binding of the edges of each crate in the assembly process and the binding together of adjacent crates shall be carried out in the same operation.

Before filling with stone, gabions 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 straining 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 1308. No loose stones shall be tipped into the crate and the practice of coursing and bonding the outer layer and filling the interior with unlaidd stones shall not be permitted.

All 1m deep gabions shall be filled in three equal layers and 0.5m 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 0.33m. 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.

(e) Securing Lids

The gabion boxes and mattress compartments shall be over filled by 50mm 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 a 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.

(f) 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 ± 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
80x100	83
100x120	114

However, the number of opening per gabion box/mattress shall not be less than the nominal length divided by 'D' on horizontal direction and nominal height divided by 'H' in vertical direction where D and H are as per Table 15.2.

1504 TEST AND STANDARD OF ACCEPTANCE

- (1) 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 15.3 from each lot of the G.I. wire received at the site of the work shall be carried out in accordance with IS 280-197 and IS 4826-1979.

Table 15.3: Scale of Sampling and Permissible Number of Defective coil

No. of coils in a lot	No. of coils randomly selected for sampling*	Permissible No. of defective coil
Up to 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.

- (2) The stones shall be tested for water absorption. At least 3 set of tests shall be made for every source of material. The test results shall meet the specified criteria.

1505 MEASUREMENT

Measurement shall be in cubic meters of gabion crates filled with stones and complete in place and the quantity shall be calculated from the dimension of the gabions indicated in the Drawing or ordered by the Engineer.

1506 PAYMENT

Payment shall be made as per respective contract unit rate which shall be the full and the final payment to the Contractor to complete the work in accordance with these Specifications.

1600 CONCRETE WORK

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SECTION 1600 – CONCRETE WORK

1601 SCOPE

This Section covers the materials, design of mixes, mixing, transport, placing, compaction and curing of concrete and mortar required in the works. It also covers reinforcement for concrete. This also includes plum concrete work.

1602 DEFINITIONS

Structural concrete is any class of concrete which is used in reinforced or plain 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 voids, blinding foundations and similar purposes 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.

1603 MATERIALS FOR CONCRETE

(1) General

The Contractor shall submit to the Engineer full details of all materials which he proposes 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 203, approved materials shall not thereafter be altered or substituted by other materials without the consent of the Engineer.

(2) Cement

Cement shall be ordinary Portland cement as per IS 8112 or IS 12269. The cement shall also meet the requirements of Clause 212. If required rapid hardening Portland cement as per IS 8041 shall be used for concrete as directed by the Engineer.

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 weather proof 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 300 mm 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 minimum gap of 500mm 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 markings and shall be stored in separate stacks. Cement in bags shall be used in the order in which it is delivered.

Cement from broken bags shall not be used in the works.

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 16.1 and 16.2 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 16.1: Test Results for Chemical Composition of Cement

Compounds %		Mean	Min.	Max.	Standard deviation
Lime	CaO				
Silica	SiO ₂				
Alumina	Al ₂ O ₃				
Iron Oxide	Fe ₂ O ₃				
Magnesia	MgO				
Sulphur	SO ₃				
Trioxide	Na ₂ O, K ₂ O				
Soda, Potash					

Table 16.2: Test Results for Physical Properties of Cement

Characteristics	Requirements	Nominal	Mean	Min.	Max.	Standard Deviation
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 Chatelier method) mm, maximum	10					
Minimum Average Compressive Strength of three mortar cubes, (N/mm ²)	16, 27*					
3 days	22, 37*					
7 days	33, 53*					
28 days						

*denotes the requirements of High Strength Portland Cement

Each set of tests carried out by the manufacturer on samples taken from cement which is subsequently delivered to site shall relate to no more than one day's output of each cement plant.

The Contractor shall constitute, from each delivery and each type of cement and not less than one sample 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 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 213 and as per the direction of the Engineer, that the 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 and approved gravel deposit. It may contain a quantity of material obtained from crushing the oversize stone in the deposit provided 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 of an artificial mixture of any of the above classes of aggregate. The 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 as specified below:

Flakiness Index: When tested in accordance with IS 2386 Part 1, the Flakiness Index of the coarse aggregate shall be not more than 25 and not more than 15 respectively for ordinary concrete and high quality concrete.

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 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 2386 Part 4.

Alkali Aggregate Reactivity: The aggregate shall comply with IS 383/3.2 notes when tested in accordance with IS 2386 Part 7.

(5) Testing Aggregates

(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 labelled 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-clauses 1603(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-clauses 1603 (3) and (4).

(b) Compliance Testing/Process Control Testing

The Contractor shall carry out routine testing of aggregates 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 aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to site provided 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 Part 2

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 As frequently as may be required according to the variability of
Reactivity: sulphate content and alkali reactivity assessed from the laboratory
tests carried out during the concrete mix design.

(6) Delivery and Storage of Aggregates

Aggregates shall be delivered to site in clean and suitable vehicles. Different type or sizes of aggregates 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 aggregates shall be arranged in such a way that drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged in such a way that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

(7) Water for Concrete and 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 or 2000 ppm sulphate ion shall not be used for mixing or curing concrete.

The Contractor shall carry out tests in accordance with IS: 456 to establish compliance with Specifications.

(8) Admixtures

(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 Bhutan.

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.

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.

1604 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 16.3, in which the class designation includes two figures. The first figure indicates the characteristic strength f_{ck} at 28 days expressed in N/mm² and the second figure is the maximum nominal size of aggregate in the mix expressed in millimetres. Letter M in the class designation stands for Mix, letters SM stand for Special Mix.

Consistence of the mix, assessed through the Slump Test where the slump is measured in millimetres, is designated 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 16.3: Concrete Classes and Strength

Classes of concrete	Consistence of Mix	Type of uses	Characteristic Strength f_{ck} (N/mm ²)	Maximum Nominal Size of Aggregate mm	Trial mixes Minimal Target Strength $f_{ct}=1.1 f_{ck}$ (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 35/40	P	High Quality	35	40	38.5	35	39
M 35/20	P	High Quality	35	20	38.5	35	39
SM 30/40	VP	Underwater	30	40	33	30	34
SM 30/20	VP	Underwater	30	20	33	30	34

(2) Design of Proposed Mixes

Concrete mixes shall comply with Clause 213.

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 1603 and in compliance with the following requirements:

- The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size.
- The cement content shall be such to achieve the strength called for in Table 16.3 but in any case not less than the minimum necessary as shown in Table 16.4
- The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and other obstructions.
- 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 above M20 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 16.4 Minimum Cement Content

Classes of concrete	Minimum cement content in kg per m ³ of compacted concrete		
	Moderate exposure	Intermediate exposure	Severe exposure
M10/75, M10/40	125	150	175
M15/40, M15/20	150	200	225
M20/40, M20/20	250	300	325
M25/20, M25/40	300	325	350
M30/40, M30/20, M30/12			
M35/40, M35/20	325	350	375
SM30/20, SM30/40	400	400	425

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 wetting and drying; traffic; corrosive fumes; heavy condensation.

Severe exposure: Surface exposed to water having a pH of 4.5 or less, groundwater 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:

- The slump of the concrete shall be determined.
- 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 larger aggregate, 200 mm cubes shall be used and in addition any pieces of aggregate retained on a 50 mm IS sieve shall be removed from the mixed concrete before casting the cubes.
- The density of all the cubes shall be determined before the strength tests are carried out.
- 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 works, the following composition is suggested for the laboratory trials:

Concrete Class	Characteristic Strength N/mm ²	Cement (kg)	Total aggregates (kg)	Fine aggregate/ Total Aggregate %	Water (max) l	Workability
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 from tests at 28 days for the nominal composition shall not be less than the Minimal Target Strength shown in Table 16.3.

One result from the modified compositions shall not be less than the nominal strength as shown on Table 16.3.

(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 proposes 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 1604 (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 16.3.

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 sample |
| For 5-20 m ³ quantity of work - | 2 samples |
| For 20 m ³ and more quantity of work - | 3 samples plus one additional for each 20m ³ or part thereof |

At least one sample shall be taken from each shifts of work.

Until compliance with the Specifications has been established the frequency of sampling shall be three times that stated above; and minimum 3 samples/day for each class of concrete production in 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 time 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 single result (average of 3 cubes) is less than the characteristic strength f_{ck} as shown in Table 16.3 under the heading "early works test cubes" and also that the average of three consecutive results is not less than $f_{ck} + 4$ as shown in Table 16.3 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/mm²) and

also the average of any group of three consecutive results shall not be less than $f_{ck}+4$ (N/mm²).

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%

where, Coefficient of Variation = Standard Deviation of results/Average value of 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/mm²), 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 1604 (3) and (4).

1605 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 proposes to use and the arrangements he proposes 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 comply 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 down at least once per week and any accumulations of mud or silt shall be removed.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

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 Specifications, 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.

1606 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 1604 (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 compaction 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.

1607 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.

(2) Preparation of Surface to Receive Concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 200.

Existing concrete surfaces shall be prepared as set out in Clause 1612. 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 method 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. 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.

(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 formwork. 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.

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 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.

During and after concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

1608 COMPACTION OF CONCRETE

Concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded item, without displacing them. Care shall be taken at arises or other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Engineer agrees another method.

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 vibrators be allowed to touch reinforcement, sheathing ducts or other embedded items.

1609 CURING OF CONCRETE

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 curing process shall commence as soon as the concrete is hard enough to resist damage from the process. The Contractor shall keep the exposed surfaces continuously wet by means of water spray or by covering with water absorbent material which shall be kept wet. Water used for curing shall be of the same quality as that used for mixing.

The Contractor shall limit the development of temperature differentials in concrete after placing by any means appropriate to the circumstances.

1610 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 1604.

1611 CONCRETING IN HOT WEATHER

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 become 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.

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°C and that the concrete does not lose any moisture during transporting and placing.

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.

1612 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 location 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 requires a different arrangement.

1613 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.

1614 REINFORCEMENT

(1) General

Reinforcement as plain bars and deformed bars and steel fabric shall comply with the following Standards:

- IS 1786 for high strength deformed steel bars
- 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.

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. Reinforcement shall be stored at least 150mm above the ground on a 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 2502. 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 temperatures below 5°C the rate of bending shall be reduced if necessary to prevent fracture in the steel.

Bending reinforcement inside the forms shall not be permitted except for mild steel bars of diameter equal to or less than 12 mm, when it is absolutely necessary.

After bending, bars shall be securely tied together in bundles or groups and legibly labelled 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 from previous operations, 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.

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.

All reinforcement shall be checked for shape, size, diameter and number where necessary. Reinforcement shall be rigidly fixed so that it remains 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.

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 or six times the bar diameter for high yield bars. Bars complying with IS 1786 or other high tensile bars shall not be bent after placing in the works.

1615 CONCRETE FOR SECONDARY PURPOSES

(1) Non-structural Concrete

Non-structural concrete shall be used only for non structural purposes where shown on the Drawing or as directed by the Engineer. This shall be compound of ordinary Portland cement and aggregates 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 1615 (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 as approved by the Engineer.

(2) No Fines Concrete

No Fines 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 1615 (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.

1616 FORMWORK

(1) Scope and Definitions

This Clause 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 Sections of these Specifications are as follows:

- Formwork means the surface against which concrete is placed to form a face. All the immediate supports necessary to retain the surface in position while concrete is placed, shall be treated as an integral part of formwork.
- False work 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 casted against formwork.
- An unformed surface means a horizontal or nearly horizontal surface which is not casted against formwork.
- An exposed face is one which will remain visible when construction has been completed.

The Contractor shall be responsible for designing and constructing 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.

(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° may be formed by screeding. Surfaces at slopes between 20° and 30° shall generally be formed if 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 previously placed concrete provided 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. It shall be shorter to the face of the concrete by 50mm.

Formwork shall not be re-used after it has suffered damage which has potential 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 Specifications in respect of surface finish, strength and rigidity. Such elements shall be set true to line and level within the tolerances prescribed in the relevant clauses of this Specification and fixed so that they do not move when concrete is placed against them.

(3) 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 suitable oil

incorporating a wetting agent, an emulsion of water suspended in oil or 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.

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 is noticed, the formwork shall be set right immediately.

(4) 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 16.5 and apply to ambient temperatures higher than 10°C. At lower temperatures or if cement other than ordinary Portland are used in concrete work the Engineer may instruct longer periods for removal of formwork.

Alternatively, formwork may be removed when the concrete has attained the strength set out in Table 16.5, 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.

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 removal 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 curing time.

Table 16.5: Minimum Periods for Formwork Removal

Position of Formwork	Minimum period for temperatures over 10° 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, columns	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.

(5) Surface Finish on Formed Surfaces

(a) Classes of Finish

The surface finish to be achieved on formed concrete surfaces shall be as shown on the Drawing and are defined hereunder:-

(i) 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.

(ii) Class F2 Finish

This finish is for surfaces which are permanently exposed to view but the highest standard of finish is not required. Forms to provide a Class F2 finish shall be faced with wrought thickened tongued and grooved boards with square edges arranged in a 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.

(iii) Class F3 Finish

This finish 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 surface.

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.

1617 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 1604.

1618 PLUM CONCRETE

(1) General

This work shall be required to provide lining of drains and drainage structures or other works as shown on the Drawings or as specified by the Engineer.

(2) Materials

The concrete shall comply with the requirements of Section 1600. The grade of concrete shall be as shown on Drawings or as directed by the Engineer. The stone shall comply with the requirements of Section 1300.

(3) Composition

Composition of plum concrete shall be 60 percent of concrete and 40 % percent of stones by volume or as instructed by the Engineer. About 3% non-shrinking agent by weight of cement shall be added to concrete at the time of mixing.

(4) Mock-up

Prior to commencement of plum concrete the Contractor shall construct a plum concrete panel of approximately 2000 mm x 1000 mm for inspection and approval of the Engineer. The thickness of mock-up shall be according to use of plum concrete in designated work.

(5) Construction

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.

(6) Tests and Standards of Acceptance

Stones shall be tested for water absorption. The test results shall meet the requirements as specified in these Specifications. Concrete shall be tested as specified in Section 1600.

1619 MEASUREMENT

(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 and 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 bars

(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 overbreak is not exceeded.

(3) Admixtures, Workability and Hardening Agents

No separate measurement of these items shall be carried out.

(4) Reinforcement

All types of reinforcement shall be measured in metric ton in the ranges as given below:

- Diameter equal to or less than 8mm
- Diameter above 8mm up to 16mm
- Diameter above 16mm

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.

(5) Formwork

Except as stated otherwise, formwork shall be measured in square metre of formwork actually in contact with the finished face of the concrete. The measurement of formwork shall be inclusive of the measurement for formwork finished surface, shoring, staging, scaffolding and other accessories required for erection and removal of the formwork. No deduction shall be made in the measurement for openings, pipes, ducts and the like, provided that the area of each is less than 0.5 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.

(6) Plum Concrete

The plum concrete shall be measured in cubic metre. Form work shall be measured in sq.m separately. Struts, bracing supports etc. shall not be measured separately. They are deemed to be included in the measurement of form work.

1620 PAYMENT

(1) Concrete

Every class of concrete shall be paid as per respective contract unit rate. The contract unit rate for respective concrete class shall be deemed to have included costs for labor, materials, tools & plants etc including any incidental costs. In addition to those specified the respective rate shall also include the cost of:

- (a) admixtures and workability agents including submission of details unless specified.
- (b) surface finish as per Sub-Clause 1616(5).
- (c) laying to sloping surfaces not exceeding 15° from the horizontal and to falls.
- (d) placing and compacting against excavated surfaces where required including any additional concrete to fill overbreak and working space.
- (e) complying with the requirements of Clauses 1601 to 1618.

(2) Reinforcement

The reinforcement shall be paid at contract unit rate. In addition to those specified, 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 supports, 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, placing and compacting concrete around reinforcement and for complying with Clause 1614.

(3) Formwork

The formwork shall be paid as per the contract unit rate. In addition to those specified, 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, fixings, cutting to waste, drilling or notching the formwork for reinforcement where required, working around pipes, ducts, conduits and waterstops, temporary openings, cleaning, dressing, removal of formwork and falsework, filling bolt holes and any remedial work and for complying with Section 1600 including all incidental works required to complete the work as per Specification.

(4) Plum Concrete

The plum concrete shall be paid at contract unit rate which shall be full and final compensation to the Contractor as specified to complete the work in accordance with these Specifications.



SECTION 1700 – CROSS DRAINAGE WORKS

1701 PIPE CULVERTS

SECTION 1700 – CROSS DRAINAGE WORKS

1701 PIPE CULVERTS

(1) Scope

This Clause covers the works for the construction of concrete pipe culverts and associated structures like wingwalls, cascades/checkdams, protection aprons etc.

(2) Materials

(a) Reinforced Concrete Pipes

Reinforced concrete pipes shall comply with the requirements of IS 458:1988.

(b) HDP Pipes

All HDP pipes to be used shall be NP4 and approved by the Engineer.

(3) Excavation for Pipes

The foundation bed for the pipe culverts/drains shall be excavated in accordance with Section 600 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 reasonably 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 of 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 from 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

Arrangements for handling including 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 to 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 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 form a self centering joint with a jointing space of 13 mm side. The jointing space shall be filled with cement sand mortar in the ration 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 joints 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 1300(2). The materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only as 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 culvert shall be flushed from end to end with water and left clean and free from obstructions.

(9) Pipes Bedding and Encasing

Pipe culvert 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 and suitably compacted granular material passing 5.6 mm sieve.

(b) Concrete Bedding

Where indicated on the Drawing, the pipes shall be laid on grade M10/40 concrete conforming to Section 1600 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 or as instructed by the Engineer

(c) Concrete Encasing

The pipes shall be fully encased in concrete if 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 from 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 602 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 culverts which have been placed and where no concrete haunch or surround is called for, selected fill of suitable material available from the excavation shall be placed 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 Catchpits

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 1300. Concrete shall conform to Section 1600 and aprons shall conform to Section 1800.

(13) Opening to Traffic

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

(14) Tests and Standard of Acceptance

The Contractor shall submit manufacturer's test certificates for each lot of pipes supplied. The test results shall meet the requirements of the relevant Specifications.

Backfilling/Refilling shall be tested in accordance with Section 600 and all the test results shall meet the criteria specified. Compaction shall be tested in each layer of backfill/refill. 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 size, 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 meters. 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 116.

The contract unit rate shall be deemed to have included costs for collar, cement jointing, labor, materials, machineries involved including any incidental costs.

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 Clauses of these Specifications.

1702 SLAB CULVERTS

(1) Scope

This Clause covers the works for the construction of slab culverts and associated structures like wingwalls, cascades/checkdams, protection aprons etc.

(2) Materials

All the materials to be used under this item shall comply with the stipulated, Clause 1300 and Clause 1600 of this specification.

(3) Excavation, Formwork and Filling

All the excavations, formwork and re-filling of trenches shall be as specified in Clause 600, Clause 1300 and Clause 1600 of this Specification.

(4) Reinforcement

The quality of reinforcement, cutting, bending and laying shall be as specified in Clause 1614. The reinforcement shall be laid allowing a minimum cover of 40 mm, 10mm diameter at 200mm spacing top and bottom.

(5) Masonry works

All stone masonry and concrete masonry works including back filling, formwork etc shall comply with Clause 1300 and Clause 1600 of this Specification.

(6) Measurement

The various items of work like excavation, backfilling, stone and concrete masonry works including ancillary works such as head walls, wing walls etc shall be measured in cubic meters as provided for in the respective Sections of these Specifications.

(7) Payment

The rate shall include the complete cost of the materials, tools & plants and labour involved including the cost for protection works such as wingwalls, checkdams, protection aprons etc as indicated in the drawings, and any incidentals to complete the work. All the activities under this item shall be paid at the respective contract unit rate, as provided under respective Clauses of this Specification.

SECTION 1800 – DRAINS AND PROTECTION WORKS

1801 GENERAL

1802 LINE DRAINS

1803 FRENCH DRAIN

1804 SLOPE STABILISATION AND SURFACE EROSION
1805 PROTECTION

1806 SUB-SURFACE DRAIN

1807 HORIZONTAL SUB-SURFACE DRAIN

1808 SCOUR PROTECTION AND RIVER TRAINING WORKS
LOG AND BOULDER BARRIER

1801 GENERAL

This Section covers the furnishing of materials and construction of slope stabilization and surface erosion protection, sub-surface drains, horizontal sub-surface drains, scour protection and river training works, log and boulder barriers, boulder wall, rock anchorage for retaining wall and rock bolting.

1802 LINED DRAINS

(A) LINED EARTHEN CATCH DRAIN

1. Excavation

The excavation for the lined catch drain shall be done according to the Drawings provided and the surplus cut material placed without compaction as a bund immediately on the valley side of the cut. The bottom of the excavation shall be levelled carefully. Any pockets of unsuitable material or loose rock in the bottom of the excavation shall be removed and the resulting cavities filled with suitable material and compacted.

Catch drains shall be minimum 3m from edge of batter, to prevent local seepage causing collapse. The surface where the drain needs to be constructed shall be prepared to the required levels/slopes with full compaction of the base to prevent future settlement. It must be ensured that the drain has uniform slope with no ponding. The surface of the drain shall be smooth finish. Catch drains shall lead to French drains at suitable locations to enable water to be transferred to side drain.

2. **Measurement:** The length shall be measured in running metre correct to 50 mm.
3. **Payment:** The cost of excavation to the required depth, leveling and or sloping to the required degree, equipment, tools, and incidentals necessary to complete the works as specified must be included in the concerned contract rate.

B) LINED L-SHAPED DRAIN

1. SCOPE

This item covers construction of lined L-shaped side drain of depth 350 mm and clear width of 1000 mm including 150mm thick PCC M20:20, cement plaster 1:4, 300mm thick RRM in CM 1:4 on hill side, including excavation, leveling and disposal of surplus earth within 50m lead.

2. EXCAVATION

Trenches shall be made along the edge of the road where the drain is to be constructed. The excavation shall be done exactly to the required profile giving specified slope. The surface shall be levelled to uniform grade/level and rammed.

For the lined drain the relevant specification for concreting, soling and plastering shall be followed. The surface of the concrete shall be finished smooth. Any rough surface shall be made smooth by adding dry mix of cement and sand 1:3 (1 cement: 3 sand) on the surface immediately after concreting when the concrete is still green. No extra shall be paid for such finishes. All work shall be carried out as per the drawing and specification or as directed by the Engineer.

The longitudinal slope of the drain must not be less than 3% and it should be uniform to avoid ponding. The cross slope shall be as per drawing unless otherwise directed by the engineer. All concrete and masonry work shall be thoroughly cured not less than 28 days before water is allowed to flow in the drain. The clear internal dimension of the drain shall be 1000 mm wide and 300 mm deep.

MEASUREMENT: The length shall be measured in running metre correct to 50mm.

PAYMENT: The rates shall include the cost of all material, tools & plants and labour involved in the above operation.

C) LINED TRAPEZOIDAL DRAIN

2. SCOPE

This item covers construction of lined trapezoidal side drain of depth 450 mm and clear width of 800 mm including 150mm thick PCC M15:20 base, cement plaster 1:4, 300mm thick RRM on both sides in CM 1:4, including excavation, leveling and disposal of surplus earth within 50m lead.

2. EXCAVATION

Trenches shall be made along the edge of the road where the drain is to be constructed. The excavation shall be done exactly to the required profile giving specified slope. The surface shall be levelled to uniform grade/level and rammed.

For the lined drain the relevant specification for concreting, soling and plastering shall be followed. The surface of the concrete shall be finished smooth. Any rough surface shall be made smooth by adding dry mix of cement and sand 1:3 (1 cement: 3 sand) on the surface immediately after concreting when the concrete is still green. No extra shall be paid for such finishes. All work shall be carried out as per the drawing and specification or as directed by the Engineer.

The longitudinal slope of the drain must not be less than 3% and it should be uniform to avoid ponding. The cross slope shall be as per drawing unless otherwise directed by the engineer. All concrete and masonry work shall be thoroughly cured not less than 28 days before water is allowed to flow in the drain. The clear internal dimension of the drain shall be 800 mm wide and 450 mm deep.

MEASUREMENT: The length shall be measured in running metre correct to 50mm.

PAYMENT: The rates shall include the cost of all material, tools & plants and labour involved in the above operation.

1803 FRENCH DRAIN

1. SCOPE

This item covers the construction of French drain, including jungle clearance, earth work in excavation, levelling of excavated earth to the sides, filling drain as per the drawings, filter material as per Section 200 and as per the drawing. Two sizes of French drains, 0.6 x 1.0 m and 1.0 x 1.5 m shall be constructed as required at site.

2. MATERIALS

The stones used for the filling of the French drain shall be as Filter Material as specified below:

GRADING REQUIREMENTS FOR FILTER MATERIAL

Sieve Designation	Per cent passing by weight		
	Class I	Class II	Class III
53 mm	-	-	100
45 mm	-	-	97-100
26.5 mm	-	100	-
22.4mm	-	95-100	58-100
11.2 mm	100	48-100	20-60
5.6 mm	92-100	28-54	4-32
2.8 mm	83-100	20-35	0-10
1.4 mm	59-96	-	0-5

710 micron	35-80	6-18	-
355 micron	14-40	2-9	-
180 micron	3-15	-	-
90 micron	0-5	0-4	0-3

Geotextile shall be as specified under Section 221. Before mass supply, the supplier must submit test certificate of geotextile materials to check its tensile and tear requirements as per BS 6906 part 3 or ASTM D4491.

3. EXCAVATION AND FILLING

The excavation for the drain shall be done according to Drawings and the cut material must be equally distributed to the left and right of the drain over an area of about 1-2 m, without compaction. For the filling of the drain, the stones may be thrown into the drain at random, careful stacking is not required.

4. QUALITY CONTROL

The excavation for the main and tributary drain shall be to the required depth as mentioned in the specification. The sides of the trench shall be excavated slightly inclined to give more stability and to prevent collapse of the vertical trench sides. The excavated earth shall be placed towards the downhill of the drain not to block the water. The excavated earth shall be placed uniformly avoiding heaps and lumps. The stone used for filling shall be filled randomly and comply with Section 1300. The geotextile shall fully cover the base and sides of the excavation, and have sufficient lap between sheets. The alignment of the drain shall be in herringbone pattern for quick collection and drainage of water

5. **MEASUREMENT:** The length of the French drain shall be measured in running metre correct to 50mm.
6. **PAYMENT:** The rate shall include for all the operation involved above to complete the work including labour, material, excavation, filling, equipment hired/owned, tools and plants and other incidentals.

1804 SLOPE STABILISATION AND SURFACE EROSION PROTECTION

(1) Scope

This Clause covers the works related to the furnishing of materials and construction of slope stabilizing measures 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 landslide stabilization 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 access tracks to enable machines to reach otherwise inaccessible areas shall not be allowed during slope stabilization works. 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 stabilization and slope protection shall include removal of individual rock blocks from 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 stabilisation work, small areas of fill may be required, such as to infill gullies. Fill material for such purposes shall consist of suitable material as defined in Clause 602 and shall be deposited and compacted by approved plant as defined in Clause 610, 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, hard, and 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 0.01 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: 1124.

(b) Construction

Construction shall comply with Sub-clause 1807(5).

(c) Tests and Standard of Acceptance

Tests and Standard of Acceptance shall comply with Sub-clause 1807(5) while the size of the stone shall comply as per Sub-clause 1804(4)(a).

(5) Grouted Stone Pitching

(a) Materials

The materials shall comply with Section 1300 of the Technical Specifications.

(b) Construction

Method of laying and thickness shall be as for dry stone pitching specified in Sub-clause 1807(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 stones 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 operation for any day's run at any location.

After the grout has been placed, the stones 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

Stones 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 1502 in Section 1500 of the Technical Specifications. The mattresses shall be assembled and filled in the same manner as for gabions specified in Clause 1503. Ties and anchorages shall be provided as shown on the Drawing.

(7) Wire Netting

Where required by the Engineer or shown on the Drawing, slopes shall be covered with wire mesh to prevent small scale reeling and erosion. The wire mesh shall conform to the requirements specified in Clause 1502 in Section 1500 of the technical Specifications and shall have a minimum thickness of SWG 10. Wire netting shall be constructed in accordance with Clause 1503.

(8) Masonry/Concrete/Reinforced Concrete Walls

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 wall shall comply with Clause 1302, and construction with Clause 1303. Mortared masonry shall be coursed and comply with Clause 1307. Dry masonry shall comply with Clause 1308. Composite masonry shall comply with Clause 1309.

Materials for concrete/reinforced concrete wall shall comply with Section 1600.

In areas where buttresses are to be constructed, the rockface to be 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 20mm in diameter and shall be of 1m 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 1600.

(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 results shall meet the specified requirements.

Six sets of test cylinder 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 18 N/mm² and 30 N/mm² respectively for 7 days and 28 days.

(10) 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 subject to the Engineer's approval. Cement and water shall meet the requirements specified in Section 1600.

(b) Construction

Method of installation, 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 true 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 150mm from the extremity of the hole. The diameter of the drill hole shall be sufficient to ensure a minimum 10mm 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 certificates for the 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 cylinder 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 1804 (9).

(11) Measurement

(a) Excavation for structures, common backfill/previous backfill/filter materials, gabion mattresses, masonry/concrete/reinforced concrete wall 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 cubic meters.

(c) Rock dowels shall be measured in running meter which are placed inside the ground and accepted by the Engineer. The exposed dowels, steel bearing plates, bolts, and

other accessories, if any, shall not be measured separately unless otherwise specified in the Bill of quantities and drawings.

- (d) Rock bolts shall be measured in numbers as placed and accepted by the Engineer. Bearing plates, washers, nuts, and other accessories shall not be measured separately.

(12) Payment

- (a) The quantity of excavation for structures, common backfill/previous backfill/filter materials, gabion mattresses, masonry/concrete/reinforced concrete wall 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 116 to complete the works as per these Specifications.

1805 SUB-SURFACE DRAINS

(1) Scope

This Clause shall cover the works related to the construction of sub-surface drainage works in slopes, slides and under road pavement. The drains shall be either main or tributary or of other types as shown on the Drawing or as directed by the Engineer.

Sub-surface drains shall consist of perforated HDP pipes surrounded by granular material laid in a trench. If specified in the contract, sub-surface drains shall also consist of perforated HDP (high density polyethylene 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 1804 (4).

(b) Cement

Cement shall be Ordinary Portland Cement complying with the requirements of Section 1600.

(c) Mortar

The mortar used for cement masonry lining shall be as specified in Sub-clause 1804 (5).

(d) Gabion Works

Gabion works shall comply with the requirements specified in Section 1500.

(e) Filter Material

Filter materials used in drains shall comply with the requirements specified in Sub-Clause 608 (1)(a) in Section 600.

(f) Geomembrane

Geomembrane shall be made of PVC or polythene sheets of at least 0.8 mm thickness, duly protected from ultra-violet 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 stapled to impair their use.

(g) Geotextile

Geotextiles used for lining of drain trenches shall be as per the requirements of Section 200. 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, high pressure as approved by the Engineer. Jointing of pipes shall be done by fine-cutting and heating with 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 which shall be compacted as specified in Clause 608(a).

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/pervious material shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm and thoroughly compacted to 93% of the MDD (heavy compaction).

Pitching shall be done as per Clause 1803. 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 out 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 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 cum. 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.

1806 HORIZONTAL SUB-SURFACE DRAIN

(1) Scope

This Clause covers the works related to the construction of horizontal sub-surface drains in slopes and slides. The horizontal sub-surface drains shall consist of HDP drainpipes covered by geotextile and placed into drilled holes.

(2) Materials

The drainage pipes for horizontal drains shall be High Density Polythene (HDP), high pressure capacity pipes of diameter 76 mm and a minimum thickness of 3 mm unless otherwise specified on Drawings or as instructed by the Engineer.

The pipes shall be perforated by drilling minimum 50 holes per metre length on the upper half of the pipe in a staggered pattern uniformly distributed with a diameter of 3mm (minimum) to 6mm (maximum). Perforation of pipes might be adjusted according to soil conditions as approved by the Engineer.

The drain pipes shall be covered by a geotextile having following specifications.

- Permeability greater than 0.01 cm/sec
- Pore width between 0.09 mm and 0.15mm

(3) Construction

Drilling of borehole of minimum diameter 110 mm shall be carried out by the Contractor to the depth as shown in Drawing or directed by the Engineer. The drill hole slope shall be 3 to 7 degrees 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-geological conditions encountered.

The pipes shall be secured in drill holes properly and rigidly in such a way that it prevents tampering and pulling out of the drilled/bored hole.

(4) Tests and Standard of Acceptance

The Contractor shall submit a sample of geotextile and HDP pipe along with manufacturer's certificate for the approval of the Engineer. It shall be ensured that the geotextile and the pipe meet the specified criteria.

(5) Measurement

The horizontal sub-surface drain shall be measured in running meter. No separate measurement shall be done for drilling and geotextile.

(6) Payment

The horizontal drain shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 116 to complete the work in accordance with these Specifications.

1807 SCOUR PROTECTION 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 not be 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:

(a) 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.

(b) For Plum Concrete

The size of the stone/rock shall not be larger than 200mm measured in any direction. The concrete to be used in plum concrete shall be as specified in Section 1600.

(c) 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 including voids shall not be more than 20% of the total volume of the pitching.

All materials to be used shall be subject to approval of the Engineer.

(3) Rip Rap

(a) Construction

The surface for rip rap shall be prepared to the line and level as indicated in the Drawing or as directed by the Engineer. To achieve this necessary excavation, filling with compaction and/or leveling shall be done as per site condition. On the prepared surface stone/rocks shall be placed individually to provide minimum space among the stones. On inclined surface the stones shall be laid in long length from bottom and not in strips in the slope. Needle like shapes and protrusions on the surfaces of stones shall be chipped off by hammer so that stones are bedded 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 least 3 set of tests shall be made for every source of material.

(4) Plum Concrete

The plum concrete work shall be as per Clause 1618 in Section 1600 of the Technical Specifications.

(5) Pitching/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 to the Drawing. Stones shall be set normal to the slope, and placed so that the largest dimension is perpendicular to the face of the slope, unless such dimension is greater than the specified thickness of pitching. The pattern of laying shall be such that the joints are broken. The spalls shall be used for tight packing and reduction of voids, which shall not exceed 15% 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 Standards of Acceptance

Stones shall be tested for water absorption 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.

The finished surface of pitching shall present an even, tight and neat appearance with no stones varying by more than 25mm from the specified surface lines and levels. The thickness of pitching, measured at right angle to the surface, shall not be less than the specified thickness.

(6) Measurement

(a) Leveling, Filling with Compaction, Trimming and/or Earth Excavation

Leveling, 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 types of measurements shall not be allowed at the same place. For computation of quantities initial and final ground levels not exceeding 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 cubic meter.

(c) Plum Concrete

Plum concrete shall be measured in cum. Formwork shall be measured in sq.m separately. Struts, bracing supports etc. shall not be measured separately. They are deemed to be included in the measurement of form work.

(d) Dry Stone Pitching/Revetment on Slopes

Dry stone pitching shall be measured in cubic meter.

Gabion work shall be in cubic meters of gabion crates filled with stones and complete in place and quantity shall be calculated from the dimension of the gabions indicated in the Drawing or ordered by the Engineer.

(7) Payment

Leveling, filling with compaction, trimming and/or earth excavation, rip-rap, plum concrete, fromwork, 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 116 to complete the works as per these Specifications.

1808 LOG AND BOULDER BARRIERS

(1) Scope

This Clause covers the required materials and techniques of constructing barriers on the valley side of the road in advance of the first width of formation cutting. The purpose of barriers is to stop the excavated material from falling further down the valley side slopes. As such the barriers need to be constructed as and where possible at distances of about 5-10 m below the road edge. The barriers have no permanent retaining function and their function needs therefore to be taken over in time by bio-engineering works (e.g. deep rooting vegetation), which will have to be taken up on the slopes above the barriers. In principle two different types of barriers are taken up in the contracts namely log barrier and boulder barrier.

(2) Log Barriers

Log barriers are ideal support structures in forest covered areas to withhold side carted spoil material. Log barriers consist of logs laid onto each other maximum 2 logs and will be held by placing them against two standing trees. Logs with girth minimum 300 mm shall be used and the total height shall not exceed 1.0 meter. Their inclination against the road alignment shall not exceed 20°.

Log barriers shall be built wherever useful in pairs. The first barrier shall be 5-10 m below the road edge. The same distance shall be kept between the first and second barrier. The exact position of the barrier shall depend on the actual site conditions and shall be determined by the Engineer. The barriers must form a closed line along the road slope so that all material tipped over the road edge shall be withheld by the barriers.

The slope of spoil material shall be protected by bioengineering as per Section 1900.

(3) Boulder Barriers

In places where boulders are available a rough type of “dry wall” can be constructed by placing boulders in a row and on top of each other. Boulder barriers shall be built where possible in pairs. The first barrier shall be 5-10 m below the road edge. The same distance shall be kept if possible between the first and second barrier. The exact position of the barrier shall depend on the actual site conditions and shall be determined by the Engineer.

The barriers must form a closed line along the road slope so that all material tipped over the road edge will be withheld by the barriers. The boulders shall be placed in such a way that larger boulders will form the first layer and smaller boulders the layer(s) above. The packing of the boulders shall be done in such a way that the barrier can withstand the pressure of the throw material.

The maximum height of the boulder barrier shall be 1.5 m and width of 1 m. The height of barrier shall depend on the size of available boulders and the amount of throw material estimated. The inclination of the row against the road alignment shall not exceed 20°.

The slope of spoil material shall be protected by bioengineering as per Section 1900.

(4) Measurement

Each type of log and boulder barriers shall be measured in running meter.

(5) Payment

The log and boulder barriers shall be paid at the respective contract unit prices which shall be the full and the final compensation to the Contractor as per Clause 116 to complete the work in accordance with these Specifications.



SECTION 1900 – BIO-ENGINEERING

- 1901 SCOPE
- 1902 PROVISION OF SEEDS
- 1903 PROVISION OF PLANT CUTTINGS
- 1904 NURSERY CONSTRUCTION
- 1905 NURSERY OPERATION AND MANAGEMENT
- 1906 TOP SOILING
- 1907 FINAL SLOPE PREPARATION FOR BIOENGINEERING
- 1908 SITE PLANTING AND SOWING
- 1909 SPRIGGING
- 1910 TURFING
- 1911 SEEDING
- 1912 JUTE NETTING WORKS
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- 1914 SITE PROTECTION
- 1915 SITE AFTERCARE AND MAINTENANCE

SECTION 1900 – BIOENGINEERING

1901 SCOPE

This Section covers all the component of bio-engineering works such as preparation of surface, spreading of top soil, turfing, sprigging, preparation of seeds and plant cuttings, nursery construction and operation, slope preparation for planting, site planting and sowing, jute netting, gabion wire bolsters and wire netting, site protection and maintenance.

1902 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. The Contractor 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's responsibility to ensure that adequate quantities of seeds are obtained in a timely manner.

The weights 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, though 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 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 damage 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 Regional Forest Office, Range 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 seeds 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 plants, as determined by the Department of Roads shall be referred to.
- (c) Seeds shall be collected from as many healthy individual plants as possible. In any event, they shall be collected from at least ten individual plants. 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 Regional Forest Office, Range 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:** The quantities shall be measured and 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, provision of safety measures, collection of seeds, separation of seeds, preparation of seeds, sun drying, packing and providing the seeds as per these Specifications.

1903 PROVISION OF PLANT CUTTINGS

The 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, though these may be specified by the Engineer. 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 of bio-engineering plants, as determined by the Department of Roads shall be referred to.

(1) Provision of Grass Cuttings

- (a) Cuttings of various types shall be taken from grass 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. Grass clumps showing stunted growth shall not be considered as sources.
- (c) Apart from the clumps, which are dug 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 Regional Forest Office, as applicable, before the making of hardwood cuttings.
- (d) The type of cuttings to be made shall depend on the species specified in the contract. If the species is still not covered, then stem and root slip cuttings shall be used.
- (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 knife where necessary. There shall be no tearing of the plant fabric.
- (f) Stem cuttings shall be made using sharp secateurs/scissors. The top cut shall be made at right angles to the stem and the bottom cut shall be made at 45° 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 Khempashing/Meringma (*Artemisia spp.*) and (*Eupatorium adenophorum*). 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 of Hardwood Cuttings

- (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 Regional Forest Office, Range 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. 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 truncheon 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.

1904 PREPARATION OF NURSERY – NOT APPLICABLE

1906 TOP SOILING

(1) General

This Clause shall consist of preparing the ground surface for top soil application, removing top soil from designated stockpiles or areas to be stripped on the site or from approved sources of the side and placing and spreading the topsoil on prepared areas in accordance with this specification at the locations shown on the Drawings, as specified or as directed by the Engineer.

Suitable equipment necessary for proper preparation and treatment of the ground surface, stripping of topsoil and for the handling and placing of all required materials shall be in good condition, and approved by the Engineer before the various operations are started.

(2) Materials

(a) Top soil

Top soil shall not contain refuse or any material toxic to plant growth, and it shall be free from inorganic subsoil, stumps, roots, brush, stones (50 mm or more in any dimension), clay lumps or similar objects. Stripping material stockpiled in earthworks operations shall be free of brush and other vegetation except that ordinary sods and herbaceous growth such as grass and weeds shall not be removed but shall be thoroughly broken up and intermixed with the soil during handling operations. To qualify as top soil, the material shall contain soil particles of which not less than 20% but not more than 80% of the material passes the 75 micron sieve as determined by the wet sieving in accordance with IS 2720-Part 4.

(b) Source of Top soil

Top soil may be obtained directly from earthwork stripping operations, from stockpiles located at other sites from previous earthwork stripping operations.

Prior to the stripping of top soil from designated areas, any vegetation, briars, stumps and large roots, rubbish or stones found on such areas, which may interfere with subsequent operations, shall be removed using methods approved by the Engineer. Heavy sod or other cover, which cannot be incorporated into the topsoil by dicing or other means, shall be removed.

When suitable topsoil is available on the site, the Contractor shall remove this material from the designated areas and to the depth as directed by the Engineer. The topsoil shall be spread on areas already tilled and smooth-graded or stockpiled in areas approved by the Engineer. The sites of all stockpiles and areas adjacent thereto which have been disturbed by the Contractor shall be graded if required and put into a condition acceptable for seeding or sprigging.

The Contractor shall remove the topsoil from approved areas and to the depth as directed. The topsoil shall be hauled to the site of the work and placed as required.

(3) Workmanship

(a) Preparing the Ground Surface

Immediately prior to dumping and spreading the topsoil on any area, the surface shall be tilled or loosened by discs or spike-tooth harrows, or by other means approved by the Engineer, to a minimum depth of 50mm to facilitate bonding of the topsoil to the subgrade soil to be covered. The surface of the area to be top soiled shall be cleared of all stones larger than 50mm in any dimension and all litter or other material which may be detrimental to proper bonding and growth of plants.

Grades on the area to be topsoiled, as shown on the Drawings or as instructed by the Engineer, shall be maintained in a true and even condition. Where grades have not been established, the areas shall be smooth-graded and the surface left at the prescribed grades in an even and properly compacted condition and shall be free-draining, to the extent practical.

(b) Placing Topsoil

The topsoil shall be evenly spread on the prepared areas to a uniform depth after compaction, as shown on the Drawings or as directed by the Engineer. Spreading shall not be done when the ground or topsoil is excessively wet, or otherwise in a condition detrimental to the work. Spreading shall be carried on so that turfing operations can proceed with a minimum of soil preparation or tilling.

After spreading, any large clods and hard lumps shall be broken down and all stones or rock (50 mm or more in any dimension), roots, litter, or any foreign matter shall be raked up and disposed by the Contractor. After spreading is completed, the topsoil shall be satisfactorily compacted by rolling. The compacted topsoil surface shall conform to the required lines, grades, and cross-sections. Any topsoil or other dirt falling upon pavements as a result of hauling or handling of topsoil shall be promptly removed.

1907 FINAL SLOPE PREPARATION FOR BIO-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 process can be dangerous and risky to personnel, the Contractor shall be responsible to ensure the safety of his/her and Client's personnel engaged for the same. 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 19.2 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 19.2 : Materials Required for Safety Measures

S. No.	Description	Quantity
1.	Safety rope (mountaineering type or similar make having a minimum of 20 mm diameter and 30 metres in length)	For every workers
2.	Safety belt similar to tree climbers or scaffolding 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) 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 to 2 horizontal, unless otherwise shown on the Drawing or instructed by the Engineer. In any event, a straight profile shall be obtained. Concavities shall be 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.
- (d) All loose material shall be removed from the slope and tipped elsewhere in an approved location.

(2) Final Preparation of Fill Slopes for Bio-Engineering

- (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.

- (d) All loose material shall be removed from the slope and tipped elsewhere in an approved location.
- (e) 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, and removal of loose materials, all labour, tools, equipment, safety harness and incidentals to complete the work as specified herein.

1908 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.
- (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 Bhutan unless otherwise specified. All species shall be covered in the current approved lists of species produced from time to time by the Field Division Offices 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 broadcasted, 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 g 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. The Contractor shall identify local herbs suitable for this. However, freshly cut herbs shall not be used because of the danger of re-sprouting 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 (e.g. Jhakrikath, *Vitex negundo*) at one metre c/c.
- (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 made as per unit rate.

(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 farmers for this work.
- (d) Seed shall be 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 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 Gawashing/Saonshing (*Alnus nepalensis*) seed it shall be at a rate of 1g 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 made rate.

(3) Site Planting of Grass Slips and Cuttings

- (a) The Contractor shall be required to carry out the planting of grass seedlings or rooted 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 complies with the specifications given in Clause 1906.
- (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 19.3.
- (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 experienced farmers for this work.

Table 19.3: Row Spacing Details

Planting configuration	Slope steepness	Spacing
Random lines	All slopes	100 mm planting drill to drill
Contour lines	Slope less than 30°	100 mm planting drill to drill and 1000 mm between the lines
	Slope 30°- 45°	100 mm planting drill to drill and 500 mm between the lines
	Slope more than 45°	100 mm planting drill to drill and 250 mm between the lines
Diagonal	Slope less than 45°	100 mm planting drill to drill and 500 mm between the lines
	Slope more than 45°	100 mm planting drill to drill and 250 mm between the lines
Downslope lines	All slopes	100 mm planting drill to drill and 250 mm between the rows

- (e) The plants supplied to the Contractor from nursery (if so provided in the Contract) shall be prepared for planting by the Contractor. 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 from the time 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 Clause 1903.
- (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 is provided in the Contract that the plants are to be collected from locations other than nurseries then utmost care shall be taken to minimize disruption to neighboring 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 300 mm between the lines. Payment will be made as per unit rate.

(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, the plants should 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 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 dug 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 *Eupatorium adenophorum* shall be avoided, since it can re-sprout 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 of seedlings and mulch, no separate payment shall be made for these items.

(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 be already 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 Clause 1903 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. *Eupatorium adenophorum*) 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 Clause 1903 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.
- (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 a 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 right angles 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 that 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 (1:10) 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 right angles 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 gap on each brush layer (i.e. 21 cuttings per linear metre).
 - (v) When a practical working length is completed, formation of second terrace shall then be started. As the excavation is undergoing, the partially backfilled brush layering terrace below shall be fully backfilled using that material that come 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) Brush layering is often done in diagonal or chevron pattern. If it is instructed so, the procedure given above shall be followed except 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 fiber) 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.
- (1) 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 cuttings, no separate payment shall be made for this item.

(7) Live Check Dam Construction

- (a) Under certain conditions, the Contractor shall be required to construct vegetation structures using hardwood cuttings. Where these are specified, the Contractor shall carry out the necessary preparation and planting works as directed by the Engineer.
- (b) The site preparation shall be completed for planting in advance; but the Contractor shall ensure that the condition of the site is good enough for the successful establishment of delicate plants.
- (c) The cuttings shall be at least 4000 mm long and 5 cm in diameter made from woody material that is 6 to 30 months old. The Contractor shall collect the cuttings from local area and transport them from there wrapped in Hessian jute. At all times, the cuttings shall be kept moist and cool as much as possible, and thus should be wrapped in wet Hessian. Under any circumstances, all plants supplied shall be planted the same day.

- (d) If the instruction to the Contractor includes the provision of cuttings, then the Engineer will specify the species and expected sources, and the Contractor shall obtain the cuttings required.
- (e) Cuttings of dabdabe (*Garuga pinnata*), kavro (*Ficus lacor*), phaledo (*Erythrina spp*) and *Gliciridia sepium* shall be a minimum of 2000 mm in length. Apart from these other species shall be used as directed by the Engineer.
- (g) Live check dams shall be constructed as given below, unless otherwise specified:
 - (i) Make a hole deep and big enough to insert vertical hardwood cuttings of the largest size available. Use a crowbar if necessary to extend the hole.
 - (ii) Insert the vertical cuttings by carefully pushing them into the hole and firming the soil around them. Do not damage the bark. They shall protrude about 300 mm above the ground.
 - (iii) Place long hardwood cuttings on the uphill side of the vertical stakes.
 - (iv) Key these horizontal members into the wall of the gully
 - (v) Backfill around the check dam and compact the soil
- (h) Measurement and Payment: The live check dam shall be measured in linear meter. The Live check dams shall be paid at the respective contract unit price which shall be the full and the final compensation to the Contractor as per Clause 116 to complete the work in accordance with these Specifications.

1909 SPRIGGING – NOT APPLICABLE

1910 TURFING – NOT APPLICABLE

1911 SEEDING – NOT APPLICABLE

1912 JUTE NETTING WORKS – NOT APPLICABLE

1913 GABION WIRE BOLSTERS, SUB-SOIL DRAINS AND WIRE NETTING – NOT APPLICABLE

1914 SITE PROTECTION

- (a) The Contractor shall protect a planted site for the period specified in the Contract. Protection shall include the prevention of damage to the site works and plants by people and domestic or wild animals. It shall also include the tending of 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 fulfill the specified requirements. The function of Warden shall be

broader than that of watchman. It shall also involve a number of routine maintenance operations.

- (b) Warden shall be matured and reliable who need little supervision for the fulfillment of his 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 not leave the site unattended 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 will require an active role of 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 so that no conflicts arise between the locals and the Contractor.
- (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 bamboos (*Bamboos mutants subs copulate*) whilst the uprights are to be made from (*Bamboos mutants subs mutants* or *Bamboos balboa*) from bamboo. 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 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 fulfill all the requirements of Section 1900.
- (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 per the instruction of the Engineer but payment shall be included in the item rate of "Site Aftercare and Maintenance".

1915 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 Clause 1905, 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 special care shall be taken in the spring, when the soil moisture deficit is at its highest.

- (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 storey 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 Environment Specialist. 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 in place. The Contractor shall follow the instructions of the Engineer in this regard.
- (11) Other maintenance operations shall be undertaken by the Contractor according to the instructions of the Engineer.

Should at any time the Engineer issue any instruction for the proper Site Protection/Aftercare and Maintenance and the Contractor does not respond within 24 hours, the Engineer shall engage other individuals/parties to carry out the works. Any costs involved by such actions shall be borne by the Contractor.

SECTION 2000 – TRAFFIC SIGNS, ROAD MARKINGS, SAFETY BARRIERS

- 2001 PERMANENT TRAFFIC SIGNS
- 2002 ROAD MARKING
- 2003 DELINEATOR POST
- 2004 ROAD MARKING STONES
- 2005 METAL CRASH BARRIER
- 2006 RETRO-REFLECTIVE POST

SECTION 2000 TRAFFIC SIGNS, ROAD MARKINGS, SAFETY BARRIERS

2001 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 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 from 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 (galvanised) 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 2.0 mm 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 cleaning, metal shall not be handled except by a device or clean canvas glove.

(f) Retro-Reflective Sheeting

The reflective sheeting shall be either 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 a 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 tack-free adhesive activated by heat in a Heat Lamp Vacuum Applicator in a manner specified by the sheeting manufacturer. 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 glare less 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) Colours 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. should 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 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 and enamel paints shall comply with relevant standards as approved by the Engineer.

(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 signs shall be of the standards as detailed in the Drawing or prescribed by the Department of Roads. The colour, configuration, size and location of all traffic signs shall be in accordance with the same standards.

The signs shall be either reflectorised or non-reflectorised as shown in the Drawing or instructed by the Engineer.

(5) Manufacturing of Signs 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 Faces

Retro-reflective sign faces shall be manufactured from aluminium plate. The background, legends, 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 Drawings or as prescribed by the Department of Roads.

Traffic sign faces shall be manufactured as one unit. Traffic signs 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 approved by the Engineer. 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 cannot be prevented without excessive waste, they shall be joined neatly and joints staggered. No sections shorter than 500 mm shall be used.

Where aluminum 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, letters 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. However, if 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 specified 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 standards as prescribed by the Department of Roads.

(b) Preparation of Surfaces and Application of Paint

The preparation of surfaces 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 framework 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 and Handling

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

Excavations 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 M10/40 as per Section 1600 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 buckling 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 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 the relevant Specifications and shall be true to the 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 provided 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 116 and also for the cost of excavation, concrete for foundation, backfill and all other incidental works required to complete the work as specified.

2002 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 standards prescribed by the Department of Roads.

This also covers the reflective glass beads installed on the pavement surface along the road centerline to identify the course of the carriageway in darkness or bad weather.

(2) Materials

Paint shall comply with the requirements of BS 6044 (1987) or equivalent or as specified by the Engineer. 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. The beads 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 circumstances thinning shall be allowed.

The colour to be used shall be bright white or yellow as shown on the Drawing or indicated in the Pavement Markings Manual, DOR.

(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 10⁰C, or when, in the opinion of the Engineer, wind strength is such that it may adversely affect the painting operations.

(4) Tools and Equipment for 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 markings be applied until at least 48 hours after the completion of the surfacing or any longer period required by the Engineer.

Before the paint is applied, the surface shall be clean and dry and completely free from 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 Markings

The lines 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 markings can be accurately applied, and in no case they shall be more than 1.5 m 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 pavement, the satisfactory working of the machine shall be demonstrated on a suitable site which is not part of the pavement. 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 pavement. 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 0.75litre/sq.m. for new surface, or as specified in the contract.

(8) Tolerances Requirements

Road markings shall be constructed to accuracy within the tolerances given below:

(a) Width

The width of the lines and other markings shall not deviate from the specified width by more than 5%.

(b) Position

The position of lines, letters, figures, arrows, and other markings 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 from the specified length by more than 150 mm.

(9) Faulty Workmanship or Materials

If any material not complying with the requirements 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 markings 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 markings or split paint shall not show up again later.

(10) 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.

(11) 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 true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer, subject to the tolerances as indicated in these Specifications.

(12) Application of Reflective Glass Beads

The reflective glass beads shall consist of plastic road studs 100x100x17.9 mm in dimension with 29 glass elements per side (2 rows) with two way reflective and 19 degree tilt for maximum reflection. It shall have two finger grips for easy handling on installation and flat base. The beads shall be installed on the road surface along the centerline of the carriageway.

(13) Measurement

The measurement of road marking shall be in linear meter for each type of marking. The measurement of reflective glass beads shall be in number.

(14) Payment

The quantities measured as provided above shall be paid at the respective contract unit rates for each type of road marking signs and reflective glass beads which shall be the full and the final compensation to the Contractor as per Clause 116 to complete the work in accordance with these Specifications.

2003 ROAD MARKER STONES – NOT APPLICABLE

(1) Scope

The work covers the supply, painting, lettering and fixing of road marker stones and shall include Standard (Kilometer) Marker Stones.

The dimensions and other details of each type of marker stones shall be in accordance with the standards in use by Department of Roads.

(2) Materials

The marker stones shall be constructed of reinforced cement concrete of grade M15/20 as per the requirements of Section 1600. The paint shall be of non-reflectorised type.

(3) Construction

(a) Marker Stone Information Details

Each Kilometer marker stone shall contain following road reference and location information:

- Route Number
- Next Important Station
- Kilometrage

(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 0.5m outside the road shoulder. Where there is no shoulder the marker stones shall be at least 1.5m 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 M10/40 as shown in the Drawing. Marker stones shall be applied with a coat of primer and two coats of enamel paint.

(4) Tests and 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 true to the 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 separately. 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 116 and also for the cost of excavation, backfilling concrete foundations and all other incidental works required to complete the work as specified.

2004 DELINEATOR POSTS – NOT APPLICABLE

(1) Scope

The work covers supplying and fixing of delineator posts. The design and painting of the posts shall be in accordance with the standards of Department of Roads.

(2) Materials

The delineator posts shall be constructed of reinforced concrete of grade M20/20 in accordance with Section 1600 or as shown in the Drawing. Paint shall be non-reflectorised paint and shall be as approved by the Engineer. It shall be fitted with reflective element as shown in the Drawing.

(3) Manufacturing

Posts shall be manufactured to the dimension shown on the Drawing or as per the standards of Department of Roads. Forms shall be smooth and have accurate dimensions. The concrete mix

shall be placed in the forms and vibrated. The posts shall be reinforced as detailed in the Drawing.

The posts 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 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 true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer.

(6) Measurement

The delineator post shall be measured in number. Excavation, preparation of foundation and backfill shall not be measured separately. 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 116 and also for the cost of excavation, backfill, painting reflecting elements (where specified) including all other incidental costs required to complete the work as specified.

2005 METAL CRASH BARRIER

(1) Scope

This Clause covers the materials required and construction of metal crash barrier. The barrier shall be single side single W-beam metal crash barrier with related accessories like beam, spacer, channel, post and fastener. The W-metal beam crash barrier shall comprise of 3mm thick corrugated sheet metal beam rail, 312 mm minimum width, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150x 75 x 5mm spaced at 2 m centre to centre, 1.8 metre high, 1.1 m below the ground/road level. The W-beam rails should be fixed on the vertical post with a spacer of channel section 150x75x5mm, 330mm long.

(2) Materials

Unless otherwise specified the materials for the metal crash barrier shall meet the following specifications:

W-Beam: It should be cold rolled formed section, minimum 3 mm thick, hot dip galvanized, 550g/sq.m and raw materials conforming to IS:5986 Gr. Fe 360(ST-37)/Fe.

Post and Spacer: It should be cold rolled formed section, minimum 5 mm thick, hot dip galvanized, 550g/sq.m and raw materials conforming to IS:5986 Gr. Fe 360(ST-37)/Fe.

The Contractor shall provide 12 months manufacturer's warranty for each items of the metal crash barrier from the date of acceptance of each item at site.

(3) Construction

The crash barrier shall be constructed at the locations shown on the Drawings or as instructed by the Engineer. The W-Beam spacer post shall be cast in M15/20 concrete block (400x400 mm) 700 mm deep. The concrete for the block shall comply with Section 1600 of the Technical Specifications. The related earthworks shall comply with Section 600 of the Technical Specifications.

After the concrete has fully set, the crash barrier shall be erected by assembling beam, spacer channel and other accessories.

(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 true to the lines, levels and dimensions as indicated on the Drawing or as directed by the Engineer, subject to the tolerances as indicated in these Specifications.

(5) Measurement

The measurement of metal crash barrier shall be in linear meter.

(6) Payment

The quantities measured as provided above shall be paid at the respective contract unit rate which shall be the full and the final compensation to the Contractor as per Clause 116 to complete the work in accordance with these Specifications.

2006 RETRO-REFLECTIVE POST – NOT APPLICABLE

(1) Scope

This Clause covers the materials and construction of retro-reflective post.

(2) Materials and Construction

Unless otherwise specified the materials for the retro-reflective post shall be 40 mm dia MS welded tube, medium grade. The post shall be 1000 mm long with 500 mm bottom portion embedded in the stone masonry parapet. The top 500 mm of the post above the parapet surface is painted in 125 mm wide alternate layers of retro-reflective paint and black enamel paint. The specifications of the paints shall be as approved by the Engineer.

(3) Measurement and Payment

The retro-reflective post shall be measured in number. The payment shall be at the contract unit price, which shall be full and final compensation to the Contractor as per Clause 116 of the specifications.

SECTION 2100 FORMS FOR QUALITY ASSURANCE SYSTEM

2102 REQUEST FOR INSPECTION SHEET

2103 NON-CONFORMANCE REPORT

2104 QUALITY ASSURANCE PLAN

2105 TEST REQUEST FORMS - CONCRETE WORKS & OTHERS

2106 MONTHLY LAB/FIELD TEST REPORT

SECTION 2100 – FORMS FOR QUALITY ASSURANCE SYSTEM

2101 SCOPE

Standard forms for quality assurance have been provided for implementation of quality assurance system as per the international code of best practice. Only the selected forms have been added and any additional forms, if required, shall be adopted during the implementation.

2102 REQUEST FOR INSPECTION SHEET (RFI)

The contractor shall submit Request For Inspection (RFI) prior to start of any work activity. Similarly the contractor shall submit the same again after the completion of the same activity. The contractor shall provide adequate time after submission of RFI so that the Engineer or his representative shall make themselves available at the site for the inspection. The contractor shall not be relieved of his obligations if the quality of works have been found to be sub-standard even after implementation of the RFI.

2103 NON-CONFORMANCE REPORT (NCR)

The Engineer shall issue Non- Conformance Report (NCR) in the event the material or works are not implemented as stipulated in the technical specification. The contractor shall propose any corrective action and shall implement the same within the time frame agreed between the Engineer and the Contractor.

2104 QUALITY ASSURANCE PLAN (QAP)

The contractor shall prepare comprehensive Quality Assurance Plan as well as condensed form of QAP as per the sample format and get it approved within a month from the date of award of the contract. The QAP shall be prepared in conjunction with the work schedule. Any updating of the work schedule will require QAP to be updated accordingly to complete the test program within the work schedule.

2105 TEST REQUEST FORM

Test request form is to be used for delivering sample material to the central laboratory or other regional laboratory outside the project. This form shall be used by the contractor to deliver sample material jointly collected by the Engineer or his representative(s) and the contractor when there are no test facilities in the field laboratory or the central laboratory of the project.

There are two type of forms (i) specifically designed for testing the crushing strength concrete cubes and (ii) the other form for testing the materials other than concrete.

2106 MONTHLY FIELD/LABORATORY REPORT FORM

Monthly laboratory/field test report shall be submitted by the contractor using sample form. The monthly test report shall cover number of test covered during the period of reporting as well as the cumulative number of test covered since the start of the project.



REQUEST FOR INSPECTION (RFI) SHEET

Appendix: _____

Name of Project: _____ Contract package: _____

To, _____
 Dear sir,
 You are kindly requested to attend the inspection as follows.

Inspection No.	IRS-01							
Site:	FC	Subgrad	GSB	Base Course	Permanent works	Drainage	Bridge	Others (Pl specify)
Inspection Date & Time:								
Location:								
Item Description:								

Your kind attention will be highly appreciated
 Yours sincerely,

 (Name)
 Designation & Company

Inspection Result Sheet

WORK ITEM	INSPECTION DATE:		
DESCRIPTION: <i>Ex: compaction is satisfactory except the subgrade which does not comply with cross slope</i>			
INSPECTION RESULT <i>see attached inspection sheet (IS)-1</i>			
	Satisfactory	Unsatisfactory	Others
signature			
CLIENT(PMU): _____	CONSULTANT: _____	CONTRACTOR: _____	

NON-CONFORMANCE REPORT(NCR) FORM

NCR No.:	Issued on:	
Name of the project:	Location:	
Implementing agency:		
Name and designation of responsible person:		
<p>What was expected?</p> <p>What has been found?</p> <p>What is the Root-cause of non-conformance?</p>		
Tech Examiner (If applicable)	Engr/Engr's Representative	Date:
Corrective action (to be proposed by Contractor Engineer and agreed by the PMU/Consultant)		
Tech examiner/Engineer (as applicable)	Contractor Engineer	Corrective action to be completed on:
Recommended recurrent prevention action:		
Responsible Agency/person for taking action:		
Tech Examiner/Engineer(as applicable)	Action to be completed on	
<i>(Please tear this part and return to PCU, RNP II not later than the stipulated date for completion of action)</i>		
NCR No.:	Issued on:	
Corrective action to be completed on:	Completed on:	
Recurrence prevention action to be completed on:	Completed on:	
(Tech Examiner/Engineer/Engr's Representative) as applicable		

Quality Assurance Plan (QAP)

Project name: _____ Contract award date: _____

Contract Package No: _____ Contract completion date: _____

Chain: _____ Contract Duration: _____

Sno	Type of work	As per specification		BoQ Qty	Unit	No of tests reqd as per site cond	Schedule		Remarks	
		No. Test(s)	Frequency(ies)				From	To		
1 Embankment construction										
	1. MDD/OMC	10	1500 m3 of soil; each soil type shall be tested	18600	m3	12	Nov 15,2010	Mar-11	as per requirement	
	2. Field density test	50	500 m3 of soil; each soil type shall	25400	m2	60				
	3. Deleterious content test	-	As & when required by the engr	-		as per site requirement				
	4. Moisture content	48	Per 250 m3 of soil	12000	m3	50				
2 Granular sub-base										
	1. Gradation	27	200 m3	5500	m3	27	Dec-10	15-Mar-10	as per requirement	
	2. Atterberg limits	12	200 m3	2500	m3	6				
	3. Density of compacted layer	30	500 m2	30	15000	m2				20
	4. CBR	11	1 test comprising of 5 random checks in 1800sqm	20000		14				
3 Road base										
4 Bituminious works										
A. Aggreagtes										
	1. Aggregates grading	85	Every 50 m3 or part of it and in every change of source	4500	m3	90	Oct 15, 2010	15-Apr-10	as per requirement	
	2. Fl (<30%)	2-3	250 m3	4500	m3	18				
	3. LAA (<40%) or	2-3	500 m3	4500	m3	9				
	4. Agg. Impact value(AIV)	2-3	500 m3	4500	m3	9				
	5. Rate of application of Agg.	2	Per run			required				
B. Bituminous Binder										
	1. Quality of binder	-	test certificate to comply with spec(50000 litres per test)	90000	litres	2	Feb-10	Apr-10	as per reqd.	
	2. Binder temperature	-	At close interval			as required				
	3. Rate of application	2	Per run			as required				

Submitted by: _____ Approved by: _____

Contractor's Engineer signature: _____ Date: _____ Engineer/Engr's representative signature: _____ Date: _____

Sample History form (For concrete /cement mortar cubes)

Organisation/Agency: To _____ _____ _____	Division/Project: Date:												
Subject: <u>Material Testing</u>													
Kindly carry out the compressive strength test on the concrete cubes with following details. Necessary test charges (if any) would be borne by.....													
Name of works: Name of contractors Firm:	Location:												
<u>Details of Concrete Cubes</u>													
1. Date of casting:	_____												
2. Mix ratio(By Weight/by Voulme):	_____ (Pl specify if different material is tested)												
3. Required Compressive strenght for:	<u>M10/M15/M20/M25/M30</u> ex cement-mortar)												
4. Specific Works/Structural member:	_____												
5. Cube identification marks:	_____												
6. Desired date of cube test	<table style="width: 100%; border: none;"> <tr> <td style="width: 30%; border-bottom: 1px solid black;"></td> <td style="width: 30%; border-bottom: 1px solid black;">7 days</td> <td style="width: 30%; border-bottom: 1px solid black;">Date: _____</td> </tr> <tr> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;">14 days</td> <td style="border-bottom: 1px solid black;">Date: _____</td> </tr> <tr> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;">28 days</td> <td style="border-bottom: 1px solid black;">Date: _____</td> </tr> <tr> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;">Others</td> <td style="border-bottom: 1px solid black;">Date: _____</td> </tr> </table>		7 days	Date: _____		14 days	Date: _____		28 days	Date: _____		Others	Date: _____
	7 days	Date: _____											
	14 days	Date: _____											
	28 days	Date: _____											
	Others	Date: _____											
<i>Note: A minimum of 3 cubes (preferably more) comprising one set shall be submitted for each works/ structural member. Cubes so prepared shall cover the entire concreting operation at any particular period .</i>													
_____ Name & Sig. of Contractor's Engr. Date:	_____ Name & Sig. of Engr/Engrs' representative Date:												
Delivered to:	Date: (copy to be retained)												

Sample History Form (For General works other than concrete cubes)

Organisatio/Agency: To _____ _____ _____	Division/Project: Date:
Subject: Material Testing	
Kindly carry out the specified tests on the sample material with following details. Necessary test charges (if any) would be borne by.....	
Name of works: Source of sample material: Name of contractors Firm:	Location: Sampled by: Date of sampling:

Details of sample material

Sample name/refence No.	Description of material	Desired tests
1. <i>Gravelly clay/ch. 10+240</i>		
2		
3		
4		

Note: In case of doubts Contractor shall enquire on the test sample quantity and tests type from the the laboratory

Name & Sig. of Contractor's Engr. Date:.....	Name & Sig. of Engr/ Engrs' representative Date:.....
Delivered to:.....	Date:..... (copy to be retained)