

TECHNICAL SPECIFICATIONS

FOR THE REHABILITATION OF AGRICUTLURAL ROADS

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1. GENERAL REQUIREMENTS

1.1 REQUIREMENTS OF SPECIFICATION

The Contractor shall fulfill all requirements and obligations of all clauses of the Specification applicable to the construction work involved in the Contract. Neither the following clauses of this Specification nor the Bill of Quantities shall limit the obligations of the Contractor under the accompanying Conditions of Contract. Where items are not included in the Bill of Quantities for any such requirements or obligations the cost of such requirements or obligations shall be deemed to be spread over all the items of the Bill of Quantities unless otherwise stated.

1.2 DRAWINGS, RECORDS AND DOCUMENTS

1.2.1 Drawings

All works shall be performed in accordance with the drawings appointed with the Contract documents and any such additional drawings as may be issued by the Engineer from time to time during the progress of the work or any drawing furnished by the Contractor and approved by the Engineer. Additional drawings (if any) will be furnished to the Contractor in due time so as to enable him to perform the work shown thereon in its proper sequence and for any advance planning that may be necessary for the efficient performance of such work. The Engineer will decide in each instance whether additional drawings are required for advance planning of the works and determine the time required for same.

1.2.2 Records and “As-built” Drawings

After the work has been completed, the Contractor shall furnish “as-built” drawings prepared whilst surveying during construction. Showing the Works as constructed together with all other information that may either be required or be useful for the operation and maintenance of the Works in the future, such as agricultural road layout, type of soil, type, dimensions and location of structures, size of pipelines and cables encountered during excavation.

All drawings and documents submitted by the Contractor shall have been checked and signed, shall be ready for issue and shall bear the title of the drawing, the scale, the date, the Contract number and name, the document number complying with an approved numbering system, the name and references of the Contractor, the name of the Employer and the Engineer, the date of approval by the Contractor and the signature of the person responsible for the approval.

Unless otherwise specified, the Contractor shall allow a minimum of 15 working days for approval of drawings and documents by the Engineer.

1.2.3 Ownership of Drawings and Documents

The Drawings and documents are issued to the Contractor for the purpose of the execution of the Works under the Contract and shall remain the property of the Employer to whom they are to be returned by the Contractor after completion of the work, as a precondition for the issue of the Certificate of Completion.

1.3 BOREHOLE INFORMATION

The Contractor shall satisfy himself as to the nature of the strata underlying the sites of the works. He may carry out at his own expense borings, tests and investigations, as he may consider necessary and utilize the information thus gained for the preparation of his tender.

Any subsoil information and test results provided by the Employer shall be given to the Contractor for his preliminary information only. Such information shall not relieve the Contractor in any way of his obligation to inspect the sites and of his sole responsibility for carrying out the works as specified and required by the Engineer and at the rates set out in the Bill of Quantities. No claims for additional payment and/or extensions of time shall be entertained in respect of data furnished to the Contractor by the Employer or the Engineer.

1.4 METEOROLOGICAL AND HYDROLOGICAL CONDITIONS

The Contractor's attention is directed to the meteorological and hydrological conditions prevailing in the project area and its vicinity. In his planning of the work and in his unit rates, the Contractor shall take these factors into account. No increase in prices and/or extension of time shall be granted due to rains, floods and/or other adverse climatological conditions in the project area and along the roads to it.

For information, the climatic conditions in Lebanon can be summarized as follows:

	Temperature (deg C°)						Relative humidity					
	Coastal zones		Mountainous zones		Bekaa Valley		Coastal zones		Mountainous zones		Bekaa Valley	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Summer	20	35	15	25	10	35	65	85	50	60	40	65
Winter	7	15	-5	10	-1	15	60	75	55	75	55	80

1.5 BILL OF QUANTITIES

1.5.1 Rates and Prices

The rates and prices inserted by the Contractor in the Bill of Quantities are to be the full and inclusive value of the work described. They are to cover all costs, expenses and general risks which may be involved, together with all liabilities and obligations set forth or implied in the Specification and other documents on which the Tender is based. They must include all plant, tools, materials, transport of men and materials, insurance and labor of every description. They must also take into account the conditions referred to in the general Conditions, and include time lost due to weather, payment of guaranteed minimum and holidays with pay. The cost of any travelling time subsistence and incentives such as overtime etc. must be included in the rates and prices.

The bidder shall provide a breakdown of all unit prices contained in the Bills of Quantities:

- breakdown of all unit rates in labor, materials, equipment, overhead, profit and other charges.
- breakdown of lump sums items if requested.

The Employer shall have the right to request, and the Contractor shall provide a further breakdown of all unit rates and prices including a detailed breakdown of "other charges".

Any item left unpriced shall be held to have had its cost included in the unit rates for other items of work.

1.6 UNITS

In this Specification, on the Drawings and in the Bill of Quantities the S.I. (Système International d'Unités) metric system of dimensioning has been employed.

Where dimensions are given in metric units for materials which are only available in Imperial dimensions, the Contractor may, subject to his obtaining prior approval of the Engineer, substitute suitable sizes of materials as are available in the Imperial system. Such approval shall not unreasonably be withheld, provided that there is no difficulty in making interface connections with any other parts of the Works.

1.7 STANDARDS

For convenience and in order to establish the necessary standards of quality, reference has been made in the Contract Documents, to specifications issued by International Standards. Such specifications shall be defined and referred to hereinafter as "Standard Specifications" and shall be the latest editions of such Standard Specifications issued prior to the issue of Tender Documents together with such additions and amendments to such editions as may have been issued prior to the same date. Subject to the approval of the Engineer, any other internationally accepted Standard which specifies an equal quality of work may be used.

In reference to Standard Specifications, the following abbreviations have been employed:

B.S.	British Standard
A.S.T.M.	American Society for Testing Materials
D.I.N.	Deutsche Industrie Normen
I.S.O.	International Organization for Standardization
A.A.S.H.T.O.	American Association of State Highway and Transport Officials
A.W.W.A.	American Water Works Association
N.F.	Normes Française
AFNOR	Association Française de Normalisation

1.8 SURVEY AND SETTING OUT

All levels used for construction shall be referred to the National Height Datum.

The Contractor shall be responsible for obtaining the location and values of the permanent benchmarks. In cases where such benchmarks do not exist, a site datum shall be agreed on with the Engineer.

Prior to the commencement of the work, the Engineer shall approve all plans showing benchmarks, limits of plot and auxiliary baselines. The Contractor, under the supervision of the Engineer, shall set out on-site and erect appropriate permanent markers, where instructed by the Engineer.

The Contractor shall employ an experienced licensed Surveyor for the duration of the Contract. He shall furnish the Engineer with a duly signed map showing the various centerlines, baselines, reference points permitting the renewal of markers and boundaries of parcels and blocks, if destroyed. Before starting and during earthwork on the site, the Contractor shall set out a net of square coordinates at distances not exceeding 10 m in each direction. A peg shall be driven at each intersection and at other relevant points and levels of peg tops and of ground at the same spot shall be measured.

The levels of the ground and the levels and dimensions of existing features shown on the drawings are not guaranteed to be correct.

Wherever dimensions or levels are marked on the drawings, such dimensions or levels shall take precedence over dimensions scaled from the drawings. Where no dimensions or levels are shown on the drawings, instructions shall be obtained from the Engineer. Large scale drawings shall be taken in preference to drawings of smaller scale.

The Contractor shall appoint and employ the necessary qualified and experienced staff to set out the work accurately and shall establish and locate all lines and levels and be responsible for the correct location of all works.

Whether or not directed by the Engineer's Representative, the Contractor shall take such levels and dimensions as may be required prior to disturbance of the ground for the purpose of measurement and these shall be agreed between the Contractor and the Engineer's Representative in writing before any of the surface is disturbed or covered up.

The Contractor shall establish parallel survey lines or other points of reference at a safe distance, permitting the re-establishment of lines and points, wherever the original lines and points must inevitably be destroyed or removed during the progress of work.

1.8.1 Surveying for Measurement of Earthwork

All intermediate and final surveying necessary for the establishment of quantities of excavation and earth fill will be done by the Contractor, who shall establish elevation points and prepare cross-sections sufficient to permit an accurate calculation of the quantities of earthwork. The Contractor shall notify the Engineer's Representative at least three days in advance of his intention to perform such measurements. The cross-sections prepared by the Contractor and approved by the Engineer's Representative shall be basis for the measurement and payment of earthworks.

1.8.2 Payment

Unless specific items are included in the Bill of Quantities, the cost of all surveying, modifications to drawings, setting out, and measuring to be done by the Contractor and all other expenses incurred by him in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

1.9 PROGRAM OF WORKS AND PROGRESS REPORTS

The time allocated for the performance and completion of all works under this Contract shall be as stated in the Estimated time schedule documents.

The information to be supplied to the Engineer shall also include drawings showing the access roads, and details of Construction Plant and Temporary Works proposed.

The Contractor when preparing his program shall take due account of the time required for the delivery of materials.

After the commencement of each and any part of the Contract, the Contractor shall forward to the Engineer in triplicate, for each calendar month, a progress

report and a chart showing the approved program, the work completed to date and the progress made during the month. Such monthly progress reports and charts shall be submitted by the Contractor to the Engineer or his Representative not later than the 6th day of the month following that to which the report and chart refer.

If requested, the Contractor's master program and cash flow estimates and subsequent updates, submitted shall, as a minimum, detail the sequence of procurement, installing, testing and commissioning, and handing over for each of the work items including each item described in the Bill of Quantities.

At least 21 days prior to taking possession of any portion of the Site and starting of work, the Contractor shall submit a detailed construction program for that portion of the Site. The detailed construction program shall be to a level to adequately identify the intended sequence of working on each individual item of work. The minimum level of detail shall not be less than that needed to identify each individual payment item included in the Bill of Quantities.

The Engineer's obligation to measure the Works in shall be dependent on the Work being programmed and progress being monitored and reported in accordance with the requirements of the Contract.

1.10 WORK SITES

1.10.1 Location of works

The Works cover the rehabilitation of agricultural road in several locations across Lebanon specified in the Work Requirement.

1.10.2 Scope of work

The works covered by this contract are summarized as follows:

- Repair of Agricultural Road, including cleaning of side channels (earth and concrete), addition of concrete channels, retaining walls. for a total road as described in the BOQ and drawings and Work Requirements.

1.10.3 Contractor's Work Area

The location of the Contractor's work area, i.e. the area or areas where the Contractor may set up his offices, stores, workshops, yards for mechanical plant, etc., and transport depots, shall be agreed beforehand with the Engineer, per approval of local authorities, and shall be such as to avoid obstruction and nuisance to the public.

The Contractor shall make his own arrangements for and pay all costs incurred in the use of such areas of land as he may require for work areas for the purpose of the Contract.

1.10.4 Conditions prevailing at site of works

The Contractor's attention is drawn to his obligation to satisfy himself, before submitting his Tender, as to the conditions prevailing at the Site of Works and its surroundings and relevant sections of the General Specification.

1.10.5 Private lands

The Contractor shall not enter upon or occupy with men, tools, or materials of any nature, any lands other than the working areas shown on the Drawings, except after consent shall have been received by him from the proper parties and a certified copy of such consent shall have been furnished to the Engineer. Any rentals or damages paid for occupying private lands shall be at the Contractor's expense.

1.10.6 Access and Construction Roads

The Contractor shall at his own expense construct and maintain within the right of way any temporary access roads and construction roads on the work sites that he deems necessary for the proper performance of the works, but the routes of such temporary roads and the method of their construction shall be subject to the Engineer's approval.

The Contractor will be permitted the use of existing roads on the Site provided that such use is coordinated with other users.

The Contractor will be permitted to use public roads as access roads to the Works only after having obtained permission in writing from the relevant Authorities and from the Engineer. The Contractor shall strictly adhere to all requirements and conditions prescribed by the relevant Authorities. The cost of preparation and maintenance of all access and construction roads and all costs incurred in complying with the requirements of this subsection shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

1.10.7 Access to work

The Engineer and his duly appointed representatives and the Employer or his representatives or agents may at any time and for any purpose whatsoever enter into and upon the work and the premises used by the Contractor. The Contractor shall provide free, proper, and safe facilities therefore.

1.10.8 Access to properties

The Contractor shall not disrupt any private or public access way without first providing alternative arrangements.

1.10.9 Existing Services

The Contractor shall make himself acquainted with the position of all existing works and services inter alia roads, sewers, stormwater drains, cables for electricity and the telephone lines, telephone and lighting poles, and water mains, before any excavation is commenced.

The Contractor will be held responsible for damage caused in the course of the execution of the Works to such existing works and services and shall indemnify the Employer, the Engineer and their agents against any claims arising from such damage (including consequential damages). Any damage caused must be made good at the Contractor's own expense.

When crossing a road in public use the Contractor shall either leave half the width of the road free for traffic or shall construct a bypass, as may be required by the road authority. The length, width and shape of any such bypass and the mode of its construction shall be as directed by the Engineer, but shall at all times permit for the passage of traffic using the main road. The Contractor shall put up warning and traffic signs, and shall employ flagmen to direct the traffic and shall mark the road crossings and put up lights from sunset to sunrise.

The Engineer's Representative may order the Contractor to repair bypasses, strengthen any temporary structures, put up additional signs or lights and generally improve the arrangements as he may deem necessary, and the Contractor shall forthwith comply with such orders. Regardless of whether or not the Engineer's Representative orders any such repairs or improvements, the Contractor shall remain solely responsible for the proper performance of all work in connection with the erection, maintenance and subsequent removal of all temporary structures required under this Clause, to the complete satisfaction of the Engineer.

Where the Works cross existing pipes, sewers, drains, channels, telephone or power lines and cables, the Contractor shall be responsible for the preservation of all such utilities in a good and serviceable condition during the execution of the Works and shall see to it that any damage done to any of the services be immediately repaired. As far as necessary, the Contractor shall construct temporary bypasses for such pipes, channels and cables and restore them to their original position after the work at the junction or crossing has been completed.

The Contractor shall construct all bypasses and do all repairs to roads, pipes, channels and cables in accordance with the requirements of the proper authorities and/or the owners thereof or shall bear the expenses of all such work done by them.

Existing access to lands, property and all other facilities shall be maintained by the Contractor during the continuance of the Works to the Engineer's satisfaction.

Where work is being carried out in the vicinity of overhead power lines the Contractor shall take special measures to ensure that all persons working in such areas are aware of the relatively large distance that high voltage electricity can "short" to earth when cranes or other large masses of steel are in the vicinity of power lines and that adequate safety precautions are being taken. The Contractor shall ensure that none of his employees commits any act which will cause damage from, or to, overhead power lines.

Unless specific items are included in the Bill of Quantities, the cost of all works required under this section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

1.11 GOVERNMENT REGULATIONS

The Contractor shall comply with all provisions of the rules, regulations and orders of Government and Municipal agencies, such as the Public Works Department, Electricity of Lebanon, and Telecommunications Authority.

The Contractor shall co-operate with the Employer in promptly furnishing any information that may be required by such governmental agencies. It shall be the obligation of the Contractor to keep himself informed of these governmental rules, regulations, and orders and the Contractor shall make the requirements of this article a part of any sub-contract he may enter into.

1.12 WATER AND POWER FOR USE IN THE WORKS

The Contractor shall be solely responsible for the location, procurement and maintenance of water supplies adequate in quality and quantity to meet his obligations under the Contract.

The Contractor shall be responsible for the supply of all electric power to meet his obligations under the Contract and for the distribution thereof.

All costs associated with the supply of water and power shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

1.13 WORKS IN THE DRY

All parts of the Works are to be carried out in the dry, and shall be kept free at all times from surface or groundwater from whatever source it may come to the satisfaction of the Engineer. Keeping the Works dry shall include all pumping

and diversion of water that may be necessary in carrying out the Works, also provision and filling-in of sump holes, installation and operation of drains, pumps, well points etc., in a manner and with equipment and materials satisfactory to the Engineer.

The Contractor shall, at his own expense, make such provision for the discharge of any water from the Works as shall be satisfactory to the Engineer and to any person having rights over the lands or watercourses over or down which such water is discharged. He shall hold the Employer indemnified against any claim that may be made through non-compliance with this section. In the event of any interference with existing land or road drains due to the construction of the Works or to the dumping of spoil, etc., within or without the limit of the Works, the Contractor shall take immediately steps to restore the drainage to the satisfaction of the Engineer and the Owners, occupiers, or Authority concerned.

Unless specific items are included in the Bill of Quantities, the cost of keeping the Works dry as specified in this section, shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

1.14 WATCHING, FENCING AND LIGHTING

The Contractor shall employ competent watchmen and guard the Works by day and night.

From the time that any portion of the Works shall be commenced, until the end of the works, the Contractor shall be responsible for protecting the public and his workmen from anything dangerous to persons or property and for the safe and easy passage of pedestrian, animal and vehicular traffic.

The Contractor shall maintain access to agricultural lands, residences, water sources, and public facilities at all times. Temporary closures shall be approved by the Engineer. Where access is interrupted, temporary diversions acceptable to the Engineer shall be provided. Emergency vehicle access shall be maintained at all times. Appropriate traffic signs, flagmen, barricades, and warning devices shall be provided in accordance with applicable regulations.

Any excavation, material dumps, soil dumps or other obstructions likely to cause injury to any person or thing shall be suitably fenced off and at night protected by red warning lights. The Contractor shall, at his own expense, and immediately upon completion of any part of the Works, fill up all holes and trenches, and level all mounds and heaps of earth which have been excavated or made in connection with the Works. The Contractor shall be responsible for the payment of all costs, charges, damages and expenses incurred or sustained on account or in consequence of any accident which may happen by reason of holes and trenches being dug and left or placed in improper locations.

Fencing shall consist of at least three 15 mm diameter hemp ropes or 4 mm diameter wires, or more, if required, stretched tightly between poles, standards, etc., securely planted in solid ground, well clear of the excavation and enclosing the spoil from the excavation. The poles, standards, etc., shall not be more than 15 m apart. If circumstances require it, they shall be placed closer and the ropes

or wires shall be stretched tight, approximately 0.40 m, 0.80 m and 1.20m, respectively, above the ground.

Banks of spoil of suitable height and form may be accepted by the Engineer in the middle of fencing. Fences and spoil banks shall be clearly marked at the ends, all corners and along the length at intervals of not more than 15 m, by means of white lime-washed boards, discs, stones or oil drums during the day and by red lamps kept burning at night. Markers shall be freshly lime- washed at regular intervals to ensure that they are white and clean.

The Contractor shall detail a man to trim and fill the lamps during the day and they shall be lit at least half an hour before sunset and not extinguished until at least one-half hour after sunrise.

If a road is closed, or partly closed, to traffic, temporary traffic signs and barricades shall be erected by the Contractor, to the satisfaction of the Engineer and the Police, to give proper warning to traffic and to the public. Road signs shall be not less than 1.20 m x 0.80 m in size, surmounted by a red circle. Lettering shall be black, on a yellow ground and shall incorporate reflective material. The signs shall be adequately illuminated at night. The Contractor shall be solely responsible for the proper control of all traffic.

The cost of watching, fencing and lighting and all other costs incurred in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates as a Lump Sum.

1.15 PRESERVATION OF TREES

No trees shall be cut down without prior permission of the Engineer who will limit the removal of trees to the minimum necessary to accommodate the Permanent Works.

If trees are cut down or damaged by the Contractor or his employees and without approval, then the Contractor shall replace such trees at his own expense with trees of not less than two years of age obtained from a reputable nursery and of species to be approved by the Engineer. The Contractor shall plant, water and ensure that the replacement trees are properly established all at his own expense.

All costs incurred in complying with the requirements of this section shall be deemed to be included by the Contractor in his unit rates for the various items on the Bill of Quantities and shall not be paid for separately.

1.16 MATERIALS

1.16.1 General

All materials shall be of the best quality throughout. Materials delivered to the Works shall be equal in all respects to the samples approved by the Engineer. The methods of stocking, mixing, transporting, fixing, placing and applying all materials shall be in compliance with the specifications and to the approval of the Engineer, who shall be kept advised of any change of plan. Materials failing to comply with the Specifications shall be immediately removed from the Works, at the Contractor's expense.

1.16.2 Manufacture's certificates

The Contractor shall furnish the Engineer with a manufacture's certificate confirming compliance to the specification in respect of all items of equipment.

The original and one copy of the manufacturer's certificate shall be delivered to the Engineer not later than 14 days prior to the intended date of delivery of the item to site.

1.16.3 Or equal clause

Wherever references to Standard Specifications, such as British Standards, are made, they shall not be construed to restrict materials to British products. Materials from other scheduled countries will be considered provided that the producer of the material certifies its conformity to the appropriate Standard Specification.

Similarly, whenever a required material or article is specified or shown in the plans by using the name of the proprietary product or of a particular manufacturer or vendor, any material or article which will perform adequately the duties imposed by the general design will be considered equal and satisfactory provided the material or article so proposed is of equal substance and function in the Engineer's opinion. It shall not be purchased or installed without his written approval.

1.16.4 Approval of Materials

Before entering into any sub-contract for the supply of any material or goods, the Contractor shall obtain the Engineer's approval in writing of the manufacturers and/or suppliers from whom he proposes to obtain such materials or goods. If requested, the Contractor shall submit to the Engineer samples of such materials and shall have them tested in approved laboratories. Such tests shall be carried out at least seven days prior to the inclusion of such

materials in the Works. The cost of all samples and tests shall be borne by the Contractor.

Should the Engineer, at any time, be dissatisfied with such material or goods or with the methods of production or operation carried out at the manufacturers or supplier's works or place of business, he shall be empowered to cancel his previously given approval of such supplier and to specify any other supplier whom he may choose for the supply of such material or goods. The Contractor shall then obtain such said material or goods from such other supplier and shall bear any additional costs thereof.

Materials which, in the opinion of the Engineer, do not comply with the Specification, shall be classified as rejected materials and shall be cut out and removed from the Works and replaced as directed by the Engineer, at the Contractor's own expense.

1.16.5 Alternative Materials

Where brand names or products of a specific manufacturer are specified in the Contract, the Contractor may, subject to the Engineer's approval (which shall not be unreasonably withheld) supply alternative materials, having similar characteristics and showing performance and quality at least equal to those specified.

Whenever the Contractor wishes to propose an alternative material, he shall submit detailed information concerning the type of material and/or product, the Vendor's name, drawings if required, test certificate, etc. If the alternative material is not approved by the Engineer, the Contractor shall supply the material originally specified in the Contract.

If the price of the approved alternative material is in excess of the material specified in the Contract, the Contractor shall not be entitled to extra payment over the rates in the Bill of Quantities.

1.16.6 Supply by Contractor

All materials required in the Works, except as otherwise provided for in the Contract, shall be supplied by the Contractor and the cost thereof shall be included by the Contractor in his rates in the Bill of Quantities.

The Contractor's Tender shall be construed as an undertaking that all the materials and equipment to be provided by the Contractor are in his possession, or readily available and will be delivered to the Site in accordance with the Time Schedule.

1.17 WORKS LOG BOOK (DAILY REPORTS)

The Engineer's Representative will keep a Works Log Book on the Site.

To assist the Engineer's Representative in keeping the Log Book, the Contractor shall supply daily to him full details in writing on the following:

1. The number of workmen of the various trades and grades employed in carrying out the Works.
2. Quantities of the various materials brought to or removed from the Site.
3. Quantities of the materials incorporated by the Contractor in the Works.
4. Constructional Plants and Contractor's equipment brought to and removed from the Site.
5. The use of Constructional Plant in the Performance of the Works.
6. Other details as requested by the Engineer's Representative.
- 7.

The Engineer's Representative may, if he so desires, use the above data to conduct the Logbook. However, such data shall not bind the Employer or the Engineer in any manner whatsoever.

The Log Book will be signed by the Engineer's Representative, and a signed copy of the daily entries will be handed to the Contractor or his authorized representative, who within 48 hours from the receipt of said copy, may object to any of the entries therein by written notice to the Engineer's Representative. Such objections by the Contractor shall be recorded in the Logbook. If the Contractor or his authorized representative has not made any such objection within 48 hours as aforesaid, he shall be deemed to have confirmed the correctness of the data entered in the Logbook.

The Contractor may enter in the Log Book his remarks regarding the performance of the Works. However, such remarks shall not bind the Employer or the Engineer.

Entries in the Log Book, except those to which the Contractor has objected in writing as described above, shall serve as evidence between the parties as to facts included therein; however, they shall not in themselves form the basis for a demand for any payment under the Contract.

1.18 RESIDENT ENGINEER'S OFFICE

Save insofar as the Contract otherwise provides, the Contractor shall provide and maintain such accommodation and amenities as he may consider necessary for all his, the Employer's and the Employer's Representative's staff and labour, employed for the purposes of or in connection with the Contract. The lump sum price includes all fencing, water supply (both for drinking and other purposes), electricity supply, sanitation, cook houses, fire prevention and firefighting equipment, heating, air conditioning, cookers, refrigerators, furniture and other

requirements in connection with such accommodation or amenities. On completion of the Contract, unless otherwise agreed with the Employer, the temporary offices, camps/housing provided by the Contractor shall be removed and the Site reinstated to its original condition, all to the approval of the Employer's Representative.

The Contractor shall not permit any of his employees to maintain any temporary or permanent living quarters within the structures forming part of the Works.

If deemed necessary, the supply and installation of an office for the Employer's Representative shall be the responsibility of the Contractor, as described below:

- Approximate total area of 25 m2 or more,
- All utilities (water, electricity, sewers & telephone) including maintenance. The Contractor will be responsible for paying charges and costs of local calls,
- Bottled drinking water,
- Secure locks for the doors and windows with security bars for windows,
- Complete custodial services,
- Office boy for maintenance and daily cleaning,
- All costs for electricity, general consumables and other services shall be borne by the Contractor.

The Contractor shall provide the office and ensure that the furniture and equipment are available for installation in the offices within 3 weeks from the date of signature of agreement. Costs of offices, furniture and equipment, as well as the offices site cleaning at project completion, shall be borne by the Contractor. Filed offices and furniture will remain the Contractor's property after completion of the Works.

1.19 FACILITIES FOR THE ENGINEER'S REPRESENTATIVE

The Contractor shall provide any necessary protective clothing and safety equipment for the use of authorized visitors to the site including the Employer and his staff and Representatives and those of any relevant authority who have reason to visit the site.

1.20 NOTICE BOARDS

The Contractor shall provide and erect sign boards at the sites where works are being executed, giving information to the public on the Project and the Employer and further details as will be prescribed by the Employer. The location and number of the sign boards at the sites will be indicated by the Engineer. The Contractor shall maintain, alter, move and adapt the sign boards from time to time as instructed by the Engineer. The display of any named subcontractors or any other information associated with the Works shall be to the approval of the Engineer.

1.21 PRECAUTIONS AGAINST CONTAMINATION OF THE WORK

The Contractor shall at all times take every possible precaution against contamination of the works. The site and all permanent and temporary works shall be kept in a clean, tidy and sanitary condition. The Contractor shall at all times take measures to avoid contamination of the existing water courses and drains by petrol, oil or other harmful materials.

1.22 SUBMITTAL PROCEDURES

1.22.1 Scope

Submittals shall include but not limited to:

1. Submittal schedule.
2. Coordination and sequencing.
3. Site layout organization chart.
4. Submittal preparation and procedure.
5. Product data.
6. Construction time schedule.
7. Design by Contractor and Design data.
8. Shop drawings and CAD produced drawings.
9. Samples.
10. Certificates.
11. Test and inspection reports.
12. Manufacturer's instructions and manuals.
13. Manufacturer's field reports.
14. Miscellaneous submittals.
15. Progress reports and Photographs.
16. Correspondence.

1.22.2 Definitions

The work related to submittals of this section, in addition to the definitions of the Contract, are further categorized for convenience as follows:

1. Product data shall include manufacturer's latest standard printed literature such as manufacturer's installation instructions, catalog cuts, colour charts, roughing diagrams, wiring diagrams, and performance curves on materials, equipment and systems for this project. Product data shall include references to applicable specification section and item number. Product data shall be in addition to the required shop drawing submittals.

2. Any design required by the Contractor, where called for in the Contract Documents, shall include calculations, and working and shop drawings (CAD).
3. Construction time schedule shall be in the form of a Gantt chart incorporating activities for all work to be performed by the Contractor, its Sub-Contractors and suppliers to be employed in or about the Site, prepared in accordance with the principles of Critical Path Method Programming.
4. Shop drawings shall include specially prepared technical data with diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, plans, sections, details and measurements in standard printed form (A4 size or A0 size for drawings). Shop drawings shall be in addition to the required product data and shall indicate applicable specification section and item numbers.
5. Samples shall include physical examples of materials, both fabricated and unfabricated, in complete units and as smaller portions of units, for visual inspection. Samples shall indicate applicable section and item numbers within that section.
6. Certificates shall include statements of suitability, certifying reports from governing agencies, industry standards and testing agencies and applicable certificates specified in each section of the specification.
7. Test and inspection reports shall include reports specified to be required in each section of the specifications.
8. Schedules shall include schedule of required submittals organized by related specification section number and sequence of submission, schedule of sequence of work and time schedule, schedule of sequence of application of specific units of work and schedule of materials, equipment and systems as listed in applicable sections of the specifications.
9. Miscellaneous submittals shall include submittals related directly to the work (non-administrative) including maintenance agreements, physical work records, copies of industry standards, record drawings, garden measurement data, operating and maintenance materials, overrun stock, security/protection/safety keys and similar information, devices and materials applicable to the work and not processed as shop drawings, product data, samples or certificates.

1.22.3 Submittal Procedures

1. General:
 - a. Transmit each submittal with the required form.
 - b. Sequentially number transmittal forms.
 - c. Mark revised submittals with original number and sequential alphabetic suffix.
 - d. Identify Project, Contractor, Sub-Contractor and Supplier and relevant drawing and detail number, and specification section number, appropriate to submittal.
 - e. Apply Contractor's stamp, signed or initialed certifying that review, approval, verification of products required, garden dimensions, adjacent construction

Work, and coordination of information are in accordance with requirements of the Work and Contract Documents.

- f. Schedule submittals to expedite Project, and deliver to Supervisor at business address instructed. Coordinate submission of related items.
- g. Identify variations from Contract Documents and product limitations which may be detrimental to successful performance of the completed Work.
- h. Allow space on submittals for Contractor and Supervisor review stamps.
- i. When revised for resubmission, identify changes made to previous submission.
- j. Distribute copies of reviewed submittals as appropriate.
- k. Instruct parties to promptly report inability to comply with requirements.
- l. Submittals not requested will not be recognized or processed.

2. Submittal Schedule:

- a. All submittals and correspondence shall be submitted to the Supervisor.
- b. Any design required by the Contractor, where called for, shall be submitted to the Supervisor for approval.
- c. All shop drawings, material and samples submittal schedules shall be submitted to the Supervisor for approval. In addition the Contractor shall submit Material delivery schedule for Supervisor's approval. The Contractor shall adhere to the approved schedules.
- d. Schedule submissions to ensure that the Supervisor is given a reasonable time to review each submission within the scheduled period of time.
- e. Certify that each submittal has been checked and approved by Sub-Contractors, installers, manufacturers and suppliers. Note any deviations from drawings or specifications. Without such an explicit note, no approval on any submittal shall be deemed a variation or a waiver of the Contractor's responsibility to fully comply with the Contract Documents.
- f. No submissions shall be processed without signed & approved certification of Contractor. This certification shall be stated on each submission as follows:
- g. Material submitted for approval has been checked for conformance with drawings and specifications for this project. Any deviation from drawings and specifications has been explicitly and clearly marked on the material or detailed in the transmittal letter.

3. Coordination and Sequencing:

- a. Coordinate preparation and processing of submittals with the Construction Program and progress so that the work will not be delayed.
- b. Coordinate and sequence submittals for work and work interfaced with other work so that the processing of submittals will not be delayed by the lack of required coordination between submittals.
- c. The obligation to coordinate the work indicated on any submittal material with other trades and with field conditions is the responsibility of the Contractor. No claim will be allowed for work that may have to be moved or replaced based on a claim that the work was placed in accordance with dimensions indicated on an approved submittal.
- d. No claim for an extension of time will be granted because of Contractor's failure to coordinate submissions.

4. Site Layout Organization Chart:
 - a. Submit to the Supervisor's approval, a site layout organization plan, and any modifications thereafter showing the Contractor's proposed layout of its temporary construction facilities and its plant/equipment on site where applicable.
5. Submittal Preparation and Procedure:
 - a. Contractor shall submit any design required by the Contractor where called for, shop drawings, material and other samples accompanied by "Design, Shop Drawings, Materials and other Samples Transmittal" forms.
 - b. The format of transmittal forms shall be to the approval of the Supervisor.
 - c. Typed transmittal forms should indicate the following:
 - Contract No.
 - Name of Contract.
 - Contractor's name.
 - Submitted by: Contractor's employee responsible for Contractor's review.
 - Specification Section: (one specification section in each submittal).
 - Transmittal No.: consecutive.
 - Date Submitted.
 - Submission No.: 1st, 2nd, 3rd, etc.
 - Bill of Quantities: Division, item and description.
 - Specification Section Paragraph: Specific paragraph under which item is specified.
 - Copies and Type: Number of copies submitted and type of material submitted.
 - Drawing No., Description and Date.
 - Contractor's Remarks: Explicit exceptions or deviations from the Contract Documents with details and reasons.
 - d. Resubmission: Re-submittal procedures shall follow the same procedures as the initial submittal (without need to resubmit material or same sample again).
 - e. Incomplete or erroneous transmittals will be returned.
 - f. Submittal Procedures by Contractor:
 - All correspondence and attachments thereto shall be submitted to the Supervisor in one original and three copies and one soft copy.
 - Two sepia and three prints and one soft copy (CAD) of each shop drawing with transmittal forms shall be submitted.
 - Two samples of each material or prefabricated component with transmittal forms shall be submitted.
 - Three copies of brochures, one of which must be an original, with transmittal forms shall be submitted.
6. Product Data:
 - a. Within 7 days after the Contract Commencement Date, submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product called for under "Submittals" in each individual specification section.
 - b. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

- c. Submit product data in triplicate for review. Indicate the actual materials being submitted for review when literature contains selections.
 - d. Indicate product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
7. Construction time schedule:
- a. Program Submittal Procedures and Requirements:
 - The Contractor shall submit his initial Construction Program for approval, in three copies and one soft copy, within 2 weeks of the Contract Commencement Date. Such initial Construction Program shall include a scheduling software Gantt chart highlighting the critical path and proving completion within contractual deadlines.
 - After approval of the Contractor's initial Construction Program, revisions and updates must be submitted on a monthly basis.
 - Revisions and monthly updates to the Construction Program shall be submitted within five (5) working days of the data date for inputting revised/updated information. The data date for the first monthly update shall be one month after approval by the Supervisor of the Contractor's initial Construction Program, and successive data dates shall be at monthly intervals. The said data date should coincide with the date of the site progress meeting at which time the records of progress are verified.
 - Each program submitted shall be signed by all principal Sub-Contractors before being submitted to the Supervisor thereby confirming that they have reviewed the said program. If any Sub-Contractor has reservations regarding his ability to comply with the program requirements to which he has appended his signature, the Contractor shall instruct the Sub-Contractor to list such reservations in writing and a copy thereof shall be submitted to the Supervisor with the program submittal for his information. Neither reservation by any Sub-Contractor, nor the fact of informing the Supervisor in respect thereof, shall relieve the Contractor of his responsibilities under the Contract in the time prescribed therein.
 - Submit a bi-weekly report detailing the preparation, submittal and approval status of shop drawings, materials and equipment, samples, and the status of materials and equipment procurement, order placed, delivery periods and site delivery dates.
 - b. Programming Costs:

All costs in establishing, maintaining, revising and updating the construction program shall be borne by the Contractor.
8. Narrative Details:
- a. The Contractor shall also prepare and submit in narrative form the following supporting data at the same time the initial time schedule is submitted. Such data shall only be resubmit 5 days before any change to them is planned to be applied:
 - b. The planned number of working days per week taking into consideration public holidays and weekends.
 - c. The planned number of shifts per day.

- d. The number of hours per shift.
- e. The planned purchasing and delivery of local and imported materials.
- f. The planned weekly manpower usage for each trade to be employed for the works.
- g. The planned productivity rates for each major work sequence.

9. Design by Contractor and Design Data:

- a. Any design required by the Contractor, where called for, with all necessary calculations, working and shop drawings, shall be submitted to the Supervisor within 7 days after the Contract Commencement Date.
- b. The design by Contractor, together with all necessary calculations, working drawings and shop drawings shall be prepared by the Contractor and by his principal Sub-Contractors for structural, architectural and electro-mechanical works, proper liaison and coordination between trades shall be attended to and ensured. Contractor shall also allow the Supervisor's access for review and approval during the preparation process.
- c. The design by Contractor shall be prepared after site dimensions have been taken. Shop drawings shall be prepared on Cad and printed on reproducible transparencies; they shall use metric units of measurement.
- d. The Supervisor's review and approval of any design required by the Contractor is for general conformance with the design concept and specifications and shall not relieve the Contractor from responsibility for errors or omissions in respect of the requirements of any standards and codes.
- e. The Contractor shall make any corrections or amendments required by the Supervisor including calculations, working drawings and shop drawings, and shall resubmit until approved. All such corrections or amendments shall be clearly indicated on the resubmitted design with all necessary calculations, working drawings and shop drawings, by the use of revision numbers in circles or triangles, or other method approved by the Supervisor.
- f. No acceptance or approval by the Supervisor of any design by the Contractor submission made by the Contractor, nor any notes, comments, stipulations, requests for clarifications, etc., made by the Supervisor upon such submissions during his review and approval thereof, shall constitute an authorization to any variation in the Contract price or scope or to any extra time for completion of the works.
- g. The Contractor shall submit Design data for Supervisor's knowledge or approval as the case may be.
- h. Submit Design data for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

10. Shop Drawings, CAD Drawings and Samples:

- a. Shop drawings shall establish actual details of manufactured or fabricated items and of work to be executed; they shall clearly identify materials, dimensions, thicknesses, components, attachments, relation with adjoining work and spaces, and all other pertinent information. Shop drawings shall clarify and amplify the design drawings and other design requirements and shall, subject to the Supervisor's approval, incorporate minor changes in design or construction as may be necessary or otherwise desirable to suit the requirements of the work. Where the Contract Documents require the

Contractor to submit samples, the same shall satisfactorily establish that the quality, construction, workmanship, finish, color, pattern and any other characteristics of the material or equipment to be provided, are in conformance with the Contract requirements and to the Supervisor's reasonable satisfaction.

- b. The Contractor shall prepare, review, coordinate and submit to the Supervisor for approval such shop drawings and samples as are required by the Contract Documents or as may be required by the Supervisor during the course of the works.
- c. At the time of making his submission, the Contractor shall inform the Supervisor in writing of any deviation between shop drawings/samples being submitted and the requirements stipulated or reasonably implied by the Contract Documents.
- d. By submitting shop drawings and samples, the Contractor represents that he has determined and verified all dimensions, relation to existing work, coordination with work and equipment to be installed later, coordination with information in previously submitted shop drawings and has verified their compliance with all the requirements of the Contract Documents. The accuracy of all such information is the responsibility of the Contractor. In reviewing shop drawings and samples, the Supervisor shall be entitled to rely upon the Contractor's representation that such information is correct and accurate. The Contractor shall be responsible for and shall make any alterations in the work due to discrepancies, errors or omissions by the Contractor. The Contractor shall be responsible for the correct locations of his work, irrespective of approval by the Supervisor, and shall pay all costs and expenses incurred by others due to improper location of his work.
- e. Sub-Contractors shall submit their shop drawings and samples through the Contractor who shall review and coordinate with his own and other Sub-Contractor's drawings and/or samples before submitting to the Supervisor. The Contractor shall be responsible in all respects for his Sub-Contractor's shop drawings and samples as if they were his own.
- f. Neither the fabrication of prefabricated items, nor the ordering of any work, materials or equipment, nor the execution of any work on site, shall commence until shop drawings and samples, relevant to the said items, work, etc., and required by the specifications, have been submitted and approved in writing by the Supervisor.
- g. Shop drawings shall be prepared by the Contractor and by his principal Sub-Contractors for structural, architectural and electro-mechanical works. Proper liaison and coordination between trades shall be attended to and ensured. Contractor shall also allow for the Supervisor's access for review and approval during the preparation process.
- h. Shop drawings shall describe accurately the method of fabrication, installation, applied finishes, types and sizes of all members and fixings, and shall, where applicable, indicate methods of marking components for site erection. Shop drawings shall be to scales approved by the Supervisor.
- i. The Contractor shall verify all dimensions and area conditions and shall check and coordinate the shop drawings and samples required in connection with a particular trade or section of the works with the requirements of other trades or section related thereto.

- j. In order to ensure proper coordination, shop drawings and samples for each system or element of work shall be submitted in a single package. The Supervisor may require that all relevant parts of a system or element be submitted before any component item is approved.
- k. Except for finish, pattern, colour and other matters in respect of which the Supervisor's decision is required in accordance with the Contract Documents, the Supervisor's review and approval of shop drawings and samples submitted by the Contractor is for general conformance with the design concept and specifications and shall not relieve the Contractor from responsibility for any deviation from, or errors or omissions in respect of the requirements of the Contract Documents, unless the Contractor has informed the Supervisor in writing of specific deviations and the Supervisor has given written approval thereto.
- l. The Contractor shall direct specific attention in writing or resubmitted shop drawings and samples to revisions other than the corrections requested by the
- m. Supervisor or previous submissions. Unless such written notice has been given, approval of a resubmitted shop drawing or sample shall not constitute approval of any changes not requested on the prior submission.
- n. In the event of written rejection by the Supervisor to a particular sample of material, the Contractor shall submit within fourteen (14) calendar days of such rejection, samples of three alternative materials for the Supervisor's approval and the Supervisor shall reject or approve all or any of these materials within fourteen (14) days of their submission. This procedure shall be repeated until such time as a sample of material is approved by the Supervisor. Failure on the part of the Contractor to obtain the Supervisor's approval, which shall not be withheld unreasonably, to all or any one sample or material shall in no way relieve the Contractor of his liabilities and obligations under the Contract.
- o. The Supervisor may at any time call upon the Contractor to submit samples of any material used or to be used in the work, including those specified in the Contract by "Brand Name", for comparison with the specification and/or approved sample. Should any such sample fail to meet the requirements of the specification and/or standard of the accepted sample, then all materials from which the sample has been taken shall be removed from the site immediately and all work executed incorporating such material shall be removed and made good to the satisfaction of the Supervisor all at the expense of the Contractor.
- p. No acceptance or approval by the Supervisor of any shop drawing or sample submission made by the Contractor, nor any notes, comments, stipulations, requests for clarifications, etc., made by the Supervisor upon such submissions during his review and approval thereof, shall constitute an authorization to any variation in the Contract price or to any extra time for completion of the works.
- q. The Contractor shall prepare his shop drawings, progress record drawings, and final as-built drawings using computer aided design and drafting techniques (CAD).
- r. All computer hardware, software and computer room necessary for the preparation of drawings using CAD shall be provided by the Contractor at no additional cost.
- s. Data indicating inappropriate or unacceptable Work may be subject to action by the Supervisor or by the Purchaser.

11. Certificates:

- a. When specified in any specification section under "Submittals", submit certification by manufacturer, installation or application sub-contractor, or Contractor to Supervisor, in quantities specified for Product Data.
- b. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
- c. Certificates may be recent or previous test results on material or Product, but must be acceptable to the Supervisor.
- d. Submit certificates in triplicate for review.

12. Test and Inspection Reports:

- a. Submit test and inspection reports called for in each specification section.
- b. Submit test reports for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

13. Manufacturer's Instructions:

- a. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Supervisor for delivery to Purchaser in quantities specified for Product Data.
- b. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

14. Manufacturer's Field Reports:

- a. Submit reports for Supervisor in duplicate.
- b. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

15. Miscellaneous Submittals:

- a. Refer to each individual specification section and the Contract Documents for additional submittal requirements.

16. Progress Reports and Photographs:

- a. The Contractor shall submit to the Supervisor each month a progress report showing actual progress by identifying activities and Works commenced and those completed during the previous week, estimated time required to complete all activities under way in relation to the programme of Works, a detailed programme for activities to be carried out during the following week and progress photographs. Such reports shall be to Supervisor's satisfaction.
- b. During the progress of the work, submit in triplicate, colored photographs taken by an approved professional photographer consisting of minimum ten (10) views, all taken where directed by the Supervisor. The prints shall be 130 x 180mm matt finish, unless otherwise stated in the Conditions of Contract. Photographs shall be taken before and after every activity.
- c. At the completion of all work final photographs shall be taken as directed by the Supervisor.
- d. Identify each print on back. Identify Name of Project, Contract Number, orientation of view, date and time of view, name and address of photographer.

- e. All soft copies (digital camera) shall be delivered to the Supervisor in their proper order and shall become the property of the Purchaser. Include typed table of contents of all photographs in chronological sequence.
- f. The Contractor shall submit photographs for all works to be covered before covering such works to the approval of the Supervisor.

17. Correspondence:

Except where more are required by the contract, all correspondence shall be through the Supervisor, and shall be submitted as follows:

One original and two photocopies of transmittals and letters including attachments/enclosures.

2. EARTHWORKS

2.1 GENERAL

2.1.1 Scope

Earthworks under this Specification include excavation for agricultural roads and open canals, excavation and backfill for structures, excavation from borrow areas, construction of embankments, compacted fill and surfaces and other earthworks and works related thereto, as required in the Works.

2.1.2 Classification of Excavation

Unless specific items for Rock Excavation are included in the Bill of Quantities, Earthwork will not be classified in accordance with the hardness of the excavated material and all excavation will be deemed to consist of Common Excavation, as defined hereafter, regardless of the actual hardness of the excavated material.

2.1.3 Natural Ground Levels

The natural ground levels, as marked on the Drawings, shall form the basis of measurement for payment for excavation, fill and all other works where the site levels have bearing and no field surveys will be made. Natural ground levels at intermediate points shall be checked on the field by the Contractor.

The Contractor shall check the natural ground levels before the commencement of earthworks, and such checking shall be made by the Contractor at his own expense, in the presence of the Engineer. The results, approvals in writing by the Engineer, shall thereafter prevail.

The cost of checking natural ground levels shall be borne by the Contractor alone, whether checking is carried out at the Engineer's request or at the Contractor's own request. No allowance will be made for normal bulking or shrinking of the soil and the Contractor shall make allowance for this in his rates.

2.1.4 Dewatering, Supporting and Fencing of Excavations

The Contractor shall, during the whole period of construction, keep the work area and all excavations dry and protected from the influx of water from any source whatsoever (rain and seepage water, water from surface and subsurface streams, groundwater, etc.) and shall provide and operate all pipes, pumps, well points and other apparatus and materials and all labour required for this purpose.

The provisions that the Contractor shall make for the discharge of any water from the Site of the Works shall be satisfactory to the Engineer and to any persons or authorities having rights over the lands through which such water is discharged. The Contractor shall keep the Employer indemnified against any claim or damage that may be caused by non-compliance with the requirements.

The sides of excavations shall be supported whenever necessary or directed by the Engineer's Representative by means of timber, steel or other type of struts, walling, boards, sheeting or any other approved system. No support work shall be removed without the approval of the Engineer.

Every precaution shall be taken by the Contractor against slips, falls, or subsidence in the excavations, but if any slips, falls, or subsidence should occur the Contractor must at once make good the same including all surface restoration and reinstatement, all at his own cost. Should any such fall, slip or subsidence disturb or weaken any foundation or support to the Works or to any adjacent structure or facility, or create empty spaces and gaps near the new works, the Contractor shall carry out such additional works as the Engineer may require in consequence thereof, such as filling the gaps so caused with concrete or other suitable material as the Engineer may direct, all at the Contractor's own expense.

The Contractor shall take all the necessary precautions during the excavation to protect his workmen and the publics. This may include, but shall not be limited to the supporting of the sides of the excavations, fencing the areas, providing warning lights and providing watchmen.

The Contractor shall be entirely responsible for the proper dewatering, supporting, fencing, lighting, watching, etc. of excavations, trenches and pits and shall not be relieved of his responsibilities under the Contract even though no objection has been raised by the Engineer to the conditions of the work.

Unless specific items are included in the Bill of Quantities, the cost of dewatering, supporting, bracing, fencing, lighting, watching, etc. of excavations, trenches and pits and any extra earthworks and labour, materials and apparatus required for them shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

2.1.5 Program and Methods of Work

In addition to the information furnished by the Contractor with his Tender, the Contractor shall, after award of Contract but no later than two weeks prior to commencement of Works, submit for the Engineer's approval detailed proposed methods of excavating, transporting and placing earth fill material, watering and compacting and any subsequent modifications thereof, together with a detailed list of quantities and type of plant to be used for all these operations. Amendments shall be made by the Contractor in accordance with any instructions issued by the Engineer before commencement of works and from time to time.

2.1.6 Excavated Materials - Handling and Disposal

As far as practicable and as determined by the Engineer's Representative, all suitable materials from excavations shall be used in the permanent construction required under the Contract.

The Contractor's operations in excavations shall be such as to yield the maximum of suitable materials for construction purposes and shall be subject to the approval of the Engineer's Representative. Where practicable, and as determined by the Engineer's Representative, suitable materials shall be excavated separately from those considered unsuitable, and the suitable materials shall be segregated by loads during the excavation operations and shall be placed in the designated final locations either directly from the excavation, or shall be placed in temporary stockpiles for later placing in the designated locations, all as directed by the Engineer's Representative.

Excavated materials that are considered unsuitable or are in excess of those required for permanent construction, shall be removed from the Site. The Contractor shall be entirely responsible for the removal of all surplus excavated material from the Site to such disposal areas as he shall have obtained at his own cost and responsibility and shall keep the Employer indemnified against any claims, charges or proceedings arising out of the transportation and disposal of such surplus excavated material.

The cost of complying with all requirements of this Sub-Section shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

2.1.7 Restoration of Waterways and Pipelines

The Contractor shall clean out and restore to their original condition all waterways or pipelines which may have been cut by the excavation or in any way damaged or silted up as a result of his operations.

Unless specific items are provided in the Bill of Quantities the cost of all additional work involved in crossing under or cutting through any waterways and pipelines and reinstating to their original condition shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

2.1.8 Restoration of Surfaces

The Contractor shall be responsible for the temporary and permanent restoration of all surfaces of roads, fields, paths, gardens, verges etc. whether public or private which are affected by his operations.

Temporary restoration shall be carried out immediately after the excavations have been refilled by returning the excavated material to the position from which it was removed and adding such suitable materials as may be required and consolidating the various

materials as the work proceeds in order to provide a surface that is adequate for the purpose that the original surface fulfilled. Temporary surfaces shall be maintained in a condition satisfactory to the Engineer and responsible Authority until the permanent reinstatement is made.

The Contractor shall be responsible for the permanent reinstatement of all surfaces already described including asphalt surfaced public roads.

Should, at any time, any trench becomes dangerous, the Engineer will be at liberty to call upon the Contractor to restore it to a proper condition at three hours' notice and, should the Contractor fail to carry out the work, have it done at the Contractor's expense.

The Contractor shall include in his rates for all materials and labor which he may have to employ in reinstating the trenches and surfaces to the satisfaction of the responsible Authority concerned.

Restoration shall be deemed to be included by the Contractor in his various unit rates for earthworks and shall not be paid for separately, except where specific items have been provided in the Bill of Quantities.

2.1.9 Equipment for Earthworks

Equipment, such as vibrating machines, may be used for compacting and consolidating the embankments, subgrades, and other areas, upon approval of the Engineer. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Watering shall be carried out by means of tank wagons, tank trucks, or distributors equipped with a suitable sprinkling device. Satisfactory equipment shall be maintained on the site at all times when embankment construction is in progress.

2.2 CLEARING AND STRIPPING

2.2.1 Clearing

The areas upon which new construction is to take place, the rights-of-way and all other such areas as may be designated by the Engineer and/or indicated on drawings as required for auxiliary purposes, (site offices and workshops, transport and machinery yards, borrow pits, stockpile sites, etc.), shall be cleared of all vegetation, shrubs and small and large trees, together with their roots, and from all other foreign and deleterious matter that may affect and interfere with the progress of the Works.

Unless otherwise specified in the Contract, clearing shall be measured by square meter. The unit rate shall include for all operations required under this Sub-Section.

No clearing shall be carried out without prior written approval of the Engineer's Representative and only such areas approved or ordered to be cleared shall be measured and paid for.

2.2.2 Stripping and Grubbing

Areas on which compacted fill is to be placed and areas of excavations from which material for fill is to be extracted, including borrow areas, shall be stripped of top soil containing organic or otherwise deleterious and objectionable matter to a depth of at least 15 cm. or to such greater depth as may be determined by the Engineer. The stripped soil shall be stored in separate dumps for subsequent re-use in covering the slopes of embankments or the borrow areas after excavation therein has been finished, or shall be otherwise disposed of as directed. Under no circumstances shall such stripped material be used as compacted fill.

Stripping shall not be carried out unless the Contractor is able to proceed immediately with the further earthworks upon the stripped areas. Over stripping shall be backfilled and compacted, at the Contractor's own expense, to the satisfaction of the Engineer.

Stripping shall be measured in square meters, computed by multiplying the width stripped by the length of stripping. The unit rate shall include for all stacking-re-spreading and running excess to spoil.

No stripping shall be carried out without prior written approval of the Engineer's Representative and only such areas approved or ordered to be stripped shall be measured and paid for.

2.3 EXCAVATION AND BACKFILL FOR PIPELINES

2.3.1 Surface Excavation to Reduce Levels

Where shown on the Drawings or required or approved by the Engineer, the Contractor shall execute surface excavation in advance of trench excavation, to the lines and grades shown on the Drawings or ordered by the Engineer.

Any surface excavation not shown on the drawings and not ordered by the Engineer that the Contractor may wish to execute for the convenience of his work shall be subject to the Engineer's approval but shall be done entirely at the Contractor's expense.

Surface excavation shall be measured in cubic meters according to the dimensions, lines and levels shown on the Drawings or directed by the Engineer. The unit rate shall include also for hauling the excavated material to fill areas, at any distance, and spreading them in layers of thickness not exceeding 20 cm. after compaction and disposal of the surplus material, all in accordance with the Drawings or as directed by the Engineer.

2.3.2 Trench Excavation for Crossing-Pipelines, Culverts, and Channels

Pipe crossing shall be excavated to the typical cross-sections shown on the Drawings, and in no case shall the trench width up to the level specified exceed that shown on the Drawings. The Contractor shall ensure that at any point the width of the pipe trench is sufficient to permit the pipeline to be laid, jointed, bedded/surrounded and backfilling to be placed and compacted around the pipeline to the Engineer's satisfaction.

The crossing invert shall, at any location, be at the proper level and crossing width of the proper dimensions to allow for sand and/or concrete bedding or surrounds as shown on the Drawings and directed by the Engineer. Where pipes are laid directly on the bottom of the crossing, the latter shall be straight and even so as to provide a good support for the pipe over its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating.

Where welding or jointing of pipes and/or accessories is required to be done in the trench or crossing, the same shall be widened and/or deepened to form bell-holes of sufficient size as directed by the Engineer's Representative so as to easily permit the proper execution of all welding, connecting and fixing works in all their stages, all necessary repairs to the pipe and coating, and for the thorough inspection of all these operations.

The length of the crossing to be kept open at one time shall be determined by the Engineer and shall in no case be exceeded. Should there be any danger that trenches or crossing may erode, then sections shall be left unexcavated for as long as possible and the laying and backfilling of pipelines shall follow excavation as soon as possible.

The excavated material shall be placed alongside the trench/crossing in such a manner as not to interfere with the work and to prevent its falling into same.

Should any part of a trench be excavated, in error, deeper than required, the extra depth shall be filled up with concrete, solely at the Contractor's expense.

Trench/crossing formations shall be in undisturbed ground. Where in the opinion of the Engineer, the formation is unsuitable for bearing, extra excavation shall be carried out under the direction of the Engineer and the level made up again with sound soil material carefully compacted or with concrete. This work shall be paid for by the Employer provided that the unsuitability of the formation is not due to the method of working of the Contractor, in which case the Contractor shall carry out the work at his own expense.

Trench/crossing walls excavated in rock shall be as nearly vertical as possible, and the Contractor shall consolidate the walls wherever they have been loosened by blasting or other reasons, and shall remove all loosened material. If rock occurs at a level higher than the required level of the trench/crossing bottom, the clearance between the pipe and the trench/crossing sides and bottom shall, where in rock, be made to the dimensions shown on the Drawings or directed by the Engineer, to allow for sand or concrete bedding or surround.

In confined areas, where the passage of excavating equipment is impossible, or where the Engineer's Representative deems the use of such equipment impracticable or undesirable for any reason whatsoever, trench/crossing excavation shall be done by hand. All

requirements specified above shall apply to trench/crossing excavation by hand. No extra payment shall be made for works in confined areas. All excavation, whether in confined or unconfined areas, shall be paid for at uniform rates as specified hereafter.

If, in the opinion of the Engineer, there is undue delay in testing the pipelines; removing surplus material; general tidying up of areas where pipes have been laid; partial restoration of maintenance of surfaces; or similar operations, then the Engineer may order that no further trenches shall be opened until the outstanding work has been carried out to his satisfaction and the Contractor shall have no ground for a claim against the Employer on this account.

No work will be started on the laying of pipes or bedding in any section of trench/crossing, until the trench/crossing formation of that particular section has been approved by the Engineer.

Once the pipeline section has been tested and the bedding and surround approved by the Engineer, the trenches shall be backfilled by layers as specified hereafter. Each layer shall be separately compacted and any subsidence resulting from insufficient compaction shall be the Contractor's liability and he shall forthwith add the necessary extra material which shall then be thoroughly compacted.

Unless otherwise specified, items for trench/crossing excavation shall apply to all kinds of soil, including rock, and the excavation will be measured for payment in linear metres measured along the centreline of the pipeline, classified by pipe diameter and for each section by average depth to invert of pipes. The average depth of a section shall be the average between adjacent manholes or as directed by the Engineer's Representative.

2.3.3 General Backfill

Where necessary, excavated material shall be sieved or sorted to remove large stones, rocks, or other particles which, in the opinion of the Engineer's Representative, may impede compaction.

a. Type A Fill

Type A fill shall be good hard well graded material screened and crushed as necessary to lie within the grading envelope given in Table 1.1. The material shall have a CBR greater than 25%.

The liquid limit should not be more than 25% and the plasticity index should not exceed 6%.

The minimum value of the sand equivalent should be 50%. The maximum value of abrasion test should be 40%.

Table 1.1: Grading Envelope for Type A Fill

Sieve Size	% by Mass Passing
75 mm	100
37.5 mm	85 - 100
10 mm	45 - 100
5 mm	20 - 65
600 microns	8 - 45
75 microns	0 -20

b. Type B Fill

Type B fill shall be clean hard fill free from deleterious material and free from stones greater than 150mm in size. The material shall have a CBR greater than 15%. The liquid limit should not be more than 40% and the plasticity index should not exceed 10%.

c. Hardcore

Hardcore shall consist of broken stone or other suitable hard material. It shall be free from clay, dust or other deleterious matter, shall not contain pieces exceeding 100mm and not more than 5% of the material shall pass through a 20mm sieve.

2.3.4 Beddings and Surrounds - Concrete

Where required, pipes shall be bedded on or surrounded by concrete, to the dimensions, lines and levels shown on the Drawings or determined by the Engineer. All concrete used for bedding and surround of pipelines shall comply, in all respects, with the provisions of technical specifications. Plain concrete and reinforced concrete shall be of Grade C20P.

Pipes shall be supported and jointed at the correct level, clear of the trench bottom upon two blocks of precast concrete of suitable height, each supporting one end of the pipe. Concrete shall then be poured and rammed beneath and around the pipes in one operation and finished off to the level and dimensions shown on the drawings.

The precast blocks shall first be properly set on the trench bottom and boned to the correct position and level. The pipes shall then be laid on the blocks and properly centered, socketed and finally brought to the correct gradient by the application of wooden wedges one on each side of the pipe and between the pipe and the concrete blocks. These wedges shall remain left-in whilst the pipes are jointed and tested, as herein

specified and during the pouring of the concrete beneath and around the pipes. Where the concrete while being poured would otherwise cause the pipes to float, pipes shall be effectively anchored to prevent such flotation.

The Contractor may, according to his own choice, pour concrete either with or without forms. Whatever the Contractor chooses; the concrete for payments shall be measured as per Drawings and no extras shall be paid for dimensions in excess of those required according to the Drawings.

2.3.5 Backfilling of Pipe Trenches

Backfilling of pipe trenches (except at joints) shall be done as soon as practicable after the pipes have been satisfactorily laid in position and jointed and in no case shall more than five pipe lengths be left uncovered after laying. Where shown on Drawings, the first stage of the backfill, up to 30 cm above the crown of the pipe, shall consist of selected material. Selected material shall be granular, free from stones, rubbish, clay and organic matter. It shall be free-draining and readily compactable. This backfill shall be spread in layers not exceeding 15 cm in thickness after compaction, and compacted at least to 95% of modified A.A.S.H.T.O. density.

The remainder of the pipe trench (from 30 cm above the crown of the pipe to the sub-base coarse of the road or to the top of the trench) shall be backfilled, after the completion of testing, by one of the following methods:

Where the pipeline crosses or runs underneath roads or pavements, backfilling shall be of type B, type A will be used when directed by the Engineer or shown on the Drawings, and shall be placed in layers not exceeding 15 cm after compaction, wetted as necessary and compacted at least 90% of modified A.A.S.H.T.O. and the last 60 cm below the road sub-base course shall be compacted at least 95% of modified A.A.S.H.T.O. density.

In open areas, where the requirements of para. (a) do not apply, the second stage backfill may be done with excavated material dumped into the trench by labors, provided that the fill material does not contain any large stones, that the trench is completely filled without leaving any voids, and the fill is finished with a neat mound raised to about 30 cm above the trench edges to allow for future subsidence.

All joints and other accessories shall be left uncovered until after the pipeline shall have passed any pressure or leakage tests that may be prescribed by the Specification.

Where the backfill cover over the pipes is less than 70 cm, the travel of the tracks or wheels of heavy equipment thereon will be strictly prohibited, and the Contractor shall use suitable small compactor, and shall be responsible for any damage caused to the pipe by non-compliance with this requirement.

The Contractor shall be responsible for any subsidence of trench backfill and shall make good any damage to road or structures caused thereby during the Period of Maintenance.

Where lengths of trench are excavated partly in rock, stony ground, or in other material unsuitable for backfilling, there may not be sufficient suitable material available from the excavation for backfilling as specified above and in such cases the Contractor shall transport suitable material from other parts of the work or from borrow areas.

2.3.6 Excavation for Canals

Excavation for canals shall be carried out and finished to the lines, grades and dimensions shown on the Drawings and to the tolerances specified hereafter.

Excavated material shall be used for earth fill in embankments and in other locations, as shown on Drawings, except for material rejected by the Engineer as unsuitable, which shall be run to spoil. Under this Section, suitable material shall be excavated, moved to fill areas, dumped and spread, as specified. The Engineer shall be entitled to designate the earth fill where individual loads of material shall be deposited.

The Contractor shall take all necessary precautions to prevent excavation beyond and below the lines and levels indicated on Drawings. Any damage to the work due to the Contractor's operations, including shattering of the material beyond the required depths and lines, shall be made good by the Contractor at his own expense. Any and all excess excavation for the convenience of the Contractor or any over excavation performed by the Contractor for any purpose or reason, except as may be directed by the Engineer in writing, shall be at the expense of the Contractor. Where required to complete the work, all excess excavation and over excavation shall be refilled, consolidated and made good with materials provided by the Contractor at his own expense, as directed by the Engineer's Representative.

Unless otherwise specified, items for excavation for canals shall equally apply to all kinds of soil, including rock, and excavation shall be measured by cubic meters of excavated material, to the lines and levels shown on the Drawings or as directed by the Engineer. The unit rate shall include for excavation, drilling and blasting, stacking, hauling excavated material in fill areas, and disposal of spoil material, all as specified in this Section.

2.3.7 Excavation and Backfill for Hydraulic Structures

All excavation for hydraulic structures shall be carried out to the dimensions, lines and grades shown on the Drawings or directed by the Engineer.

Excavations on or against which concrete or compacted fill is to be placed, shall be clean and free from stones, clods, debris and other loose material. Where the bottom of an excavation does not provide a solid basis for casting concrete, it shall be consolidated by tamping and/or watering as necessary until the required density is obtained.

Any over excavation in the bottom of the structure shall be cleaned and backfilled with concrete or selected backfill compacted to the density of the adjacent natural soil. Over excavation in rock shall be backfilled with the concrete of the structure or with dry stone pack, as directed by the Engineer. Any and all excess excavation for the convenience of the Contractor for any purpose or reason, except as may be directed by the Engineer in writing, and all refilling of such over excavation as specified, shall be at the expense of the Contractor.

Where possible, concrete foundations and blocks shall be cast against the undisturbed sides of the excavation. Where over excavation beyond the lines of the structure is

unavoidable due to the nature of the ground, because of the shape of the structure or for any other reason, the space between the structure and the faces of the excavation shall be backfilled to the original ground level (whether natural or reduced) as specified hereafter for backfilling.

Excavated material, to the extent that it is required and suitable, shall be put aside for use in backfill. Surplus excavated material shall be either used for backfill in other locations on the site, or shall be otherwise disposed. Wherever required, the Contractor shall obtain suitable material for compacted backfill from borrow areas.

Backfill shall be carried out to the lines and grades shown on the Drawings. The backfill material shall be placed in horizontal layers not exceeding 20 cm in thickness after compaction with minimum thickness 50cm. The backfill material shall completely and firmly fill the spaces between the excavation lines and the structure without leaving any voids, and shall be compacted to the density of the adjacent natural earth. The sides and bottom of the excavation shall be moistened before backfilling and so shall the backfill material, in order to obtain the moisture content necessary for the required compaction. Every layer shall be compacted by pneumatic tampers approved by the Engineer.

Unless otherwise specified, items for excavation and backfill for structures shall equally apply to all kinds of soil, including rock.

2.3.8 Road Reinstatement

a. Reinstatement of Surfaces

All surfaces whether public or private which are affected by the Works shall be reinstated.

Reinstatement of surfaced roads shall be carried out to the approval of the relevant authority. The

responsible authority shall have the right to carry out final reinstatement at the Contractors expense.

Trenches in open ground shall be reinstated to the condition in which the ground was before excavation was commenced. The final surface of the trench shall be flush with the surrounding ground.

If at any time any reinstatement deteriorates, the Contractor shall restore it to a proper condition immediately.

Should the Contractor not remedy the defect to the Engineer's satisfaction forthwith any remedial work considered necessary may be undertaken by the Employer and/or the responsible authority at the Contractor's expense.

The trenches shall be refilled and rammed solid as specified in the Contract and shall not be topped up above the original surface level to allow for settlement.

If any trench becomes dangerous the Engineer may call upon the Contractor for its reinstatement and failing this to have the work done by others at the Contractor's expense.

b. Safety of Excavation in Roads

Where the surface of the road (other than that which lies immediately above the trench) is damaged either by the concentration of traffic caused by an open trench, by subsidence or other causes arising from the operations of the Contractor, he shall permanently reinstate the whole of the surface so damaged to its original condition.

The Contractor shall ensure that trenches and reinstatement are maintained in a safe condition and shall take immediate action to remedy any deterioration which renders the works unsafe. If in the opinion of the Engineer any excavation or reinstatement is in a dangerous condition the Contractor shall immediately remedy the defect. Should the Contractor fail to carry at the reinstatement promptly the work may be carried out by others at the Contractor's expense.

2.4 EXCAVATION FROM BORROW AREAS

Wherever required or directed by the Engineer, the Contractor shall obtain suitable material for compacted fill from borrow areas. Such suitable borrow material shall be excavated, moved to fill areas and spared as specified. The locations and boundaries of the borrow areas as well as the depths and slopes of excavation therein shall be as determined or approved by the Engineer's Representative. Before commencing to extract filling material from any borrow area, the Contractor shall strip its surface and shall also remove therefrom all material which is, in the Engineer's opinion, unsuitable for filling. The surface of the borrow shall be left in a reasonably smooth and even condition, as approved by the Engineer's Representative.

No excess borrow material shall be brought to fill areas. Unnecessary material shall be rejected and dumped and shall not be measured for payment.

Measurement for payment of excavation in borrow areas shall be made only for excavation of borrow material actually used as fill, to the lines and dimensions prescribed by the Engineer's Representative. Measurement shall be by cubic meters and the unit rate shall include for stripping (which shall not be measured and paid for) and for removing unsuitable material, hauling to fill areas at any distance. All materials from borrow pits placed in embankments and compacted backfill will again be included for payment under the applicable rates of the Bills of Quantities for compacting such earthwork. Provided always that the cost of borrowed material has not been specified to be included in those relevant pay items for which the same borrowed material is to be supplied.

2.5 EMBANKMENTS AND COMPACTED FILL

2.5.1 General

Wherever the term “embankment” is employed it shall also mean “compacted fill”, unless the distinction between those two terms is clearly emphasized.

Embankments shall be constructed to the lines and grades shown on the Drawings. Where grassing is required, a compacted fill embankment shall be constructed up to the underside of the layer of topsoil, as shown on the Drawings.

No brush, roots, sod, or other perishable or unsuitable materials shall be placed in the embankments. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in embankment construction will be determined by the Engineer. The Contractor shall maintain the embankment in an approved manner until the final completion and handing over of all the Works.

The embankment operations shall be so conducted, and the various soil strata shall be placed so as to produce a soil structure as shown on the typical cross sections, or as directed by the Engineer. The slopes of the division lines between zones and/or portions of the embankment are tentative and shall be subject to variation, at any time prior to or during construction, and the Contractor shall be entitled to no additional allowance above the unit rates in the Bill of Quantities, by reason of such variations. The embankment for each portion shall be maintained approximately level throughout the entire length of each layer from abutment to abutment. All openings through the embankment required for construction purposes shall be subject to approval, and such openings shall be constructed so that the slope of the bonding surface between embankment in place and embankment to be placed is not steeper than 3:1. The bonding surface of the embankment in place shall be prepared as provided for embankment foundations.

The Contractor shall be responsible for the stability of all embankments made under the contract and shall replace any portion which, in the opinion of the Engineer, has become displaced due to carelessness or negligence on the part of the Contractor.

Where excess spoil, or other material for which compaction is not specified, is dumped and spread, the Contractor shall route his equipment, both when loaded and when empty, to travel over the entire area of the above-mentioned material. No payment will be made for this operation, and its cost shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities.

When the state of the weather is such that it would adversely affect the placing of fill, all embanking shall be stopped. In particular, embanking work will not be permitted during rain nor for such time afterwards as the Engineer may judge to be necessary to allow the upper layers in the embankment to dry to their correct moisture content as directed by the Engineer.

At all times during dry weather, whether embanking is taking place or not, the surface of the embankment is to be watered everywhere as directed by the Engineer or protected to his satisfaction to prevent undue cracking of the surface. Watering is to be done by means of tankers, sprinklers or other methods approved by the Engineer.

Any material not complying with the specified density or moisture content shall be replaced in the embankment at the Contractor's own expense notwithstanding the fact that it may be overlaid by more recently placed material.

2.5.2 Preparation of Foundation

No material shall be placed in any section of the embankment until the foundation for that section has been suitably prepared and approved by the Engineer's Representative.

All excavation made for test pits or other subsurface investigations, and all other existing cavities found within the area to be covered with earth fill which extend below the established lines of excavations for the embankment foundations shall be filled with compacted earth fill. The foundation for earth fill, where in clayey soil, shall be scarified, wetted and compacted as specified for the earth fill to be placed thereon. Where the foundation is granular material, it shall be compacted to the same density as specified by the overlaying earth fill. Surfaces upon or against which the earth fill portions of the embankment are to be placed shall be cleaned of all loose and objectionable materials in an approved manner by hand-work or other effective means immediately prior to placing the first layer of earth fill. The surfaces of each portion of the foundation, immediately prior to placing the earth fill, shall have all water removed from depressions and shall be properly moistened and sufficiently clean to obtain a suitable bond with the earth fill. Where compaction of fill is to be started or continued after the previous layer has been in place for over 6 hours, the area shall be harrowed to a depth of 20 cm, wetted and compacted to the required degree of compaction.

2.5.3 Compaction Control

Compaction shall be controlled by field density and field moisture tests, or by such other tests as prescribed by the Engineer.

The densities of the compacted earth materials shall be defined as follows:

- Modified A.A.S.H.T.O. Density shall mean the maximum dry density obtained from the compaction test in accordance with the A.A.S.H.T.O.-T-180-61 (method D) test or the (identical) A.S.T.M.-D-1557 (method D) test.
- Relative Density shall be defined by the following formula (in accordance with the U.S. Bureau of Reclamation Earth Manual Designation E-12):

$$D_d = \frac{Y_d \max - Y_d}{Y_d \max - Y_d \min} \times 100$$

Where

D_d = Relative density

Y_{dmax} = greatest dry density obtained by laboratory
 Y_{dmin} = least dry density obtained by laboratory

Y_d = the dry density at which the soil is to be placed or the in place dry density

The field density of compacted material in place shall be determined by the A.A.S.H.T.O.-T-191-61 method or by the identical A.S.T.M.-D-1556-64 method. Field moisture content shall be determined by the A.S.T.M.-D-2216-63-T method.

Samples of all fill materials, both before and during placement, shall be taken for testing at frequent intervals. The following tests shall be performed:

- Tests to determine the maximum dry density and the optimum moisture content. The number of samples for these tests shall be as determined by the Engineer but not less than one sample per 1,000 m³ of fill shall be taken.
- Field density tests. The number of samples for these tests shall be as determined by the Engineer, but not less than one sample per 1,000 m³ of compacted fill or one sample per day, whichever is larger.

For the performance of all the above-mentioned tests, the Contractor shall provide a fully equipped field laboratory and the necessary trained personnel for sampling and testing, all subject to the Engineer's prior approval. All costs for providing the field laboratory and the necessary personnel and for sampling, testing, transportation, etc., shall be deemed to be included by the Contractor in his unit rates for the various items of earthworks in the Bill of Quantities and shall not be paid for separately.

2.5.4 Placing and Compacting - General

Embankment materials shall be deposited in horizontal layers over the entire width of the embankment and compacted to the required densities as shown on the Drawings or as specified.

Embankments shall be formed of satisfactory materials. The thickness of each layer shall not exceed the thickness shown on the Drawings or as specified. In the construction of embankments, starting layers shall be placed in the deepest portion of the fill, and as placement progresses, layers shall be constructed approximately parallel to the finished grade line.

The material in the layers shall be brought to the optimum moisture content before rolling is started to obtain the prescribed compaction. Wetting or drying of the material and manipulation to secure a uniform moisture content throughout the layer shall be required. Should the material be too wet to permit proper compaction or rolling, all work on all portions of the embankments thus affected shall be delayed until the material has dried to the required moisture content. Sprinkling shall be done with sprinkling wagons, pressure distributors,

or other approved equipment that will sufficiently distribute the water. Sufficient equipment to apply the required water shall be available at all times.

The optimum moisture content shall be determined by the Engineer and the actual content shall not vary from the required one by more than plus 4 or minus 2 percent. This optimum moisture content, determined by the Engineer as required for compaction purposes, shall be uniform throughout each layer of the earth-fill prior to and during the compacting.

The distribution of materials shall be such that the compacted fill be homogeneous and free from lenses, pockets streaks or other imperfections.

The number of successive passes of the compacting equipment over each and every point in any layer shall be not less than six. The overlapping of two adjacent passes shall be not less than 30 cm. The Engineer's Representative shall have the right to test every layer. However, the Contractor shall not be permitted to start work on the successive layers without the Engineer's Representative's permission, irrespective of whether tests have been made or not.

Where due to small width of required fill or any other reason, compaction of material in horizontal layers will, in the Engineer's opinion, be impracticable, the Engineer may permit the use of other equipment and procedures such as compaction by mechanical tampers or spreading the material in small quantities in layers parallel to the slope and compacting same by cylindrical rollers applied along the slopes, or otherwise. Compaction shall be carried out to the Engineer's satisfaction and to the specified density.

After compaction has been completed as specified, all surfaces and slopes shall be trimmed and smoothed to accuracy specified hereafter. The cost of such trimming and smoothing shall be deemed to be included in the various rates for construction of embankments.

2.5.5 Methods of Measurement and Payment

The supply of fill material, including its hauling and spreading and running of surplus to spoil, shall be paid in cubic meter, whether from borrow areas or from excavations for roads, structures, etc.

Compaction of Embankments shall not be paid for separately, it shall be included. No payment shall be made for additional material required to be added due to Settlement, and the Contractor shall make due allowance for this in his rates.

The unit rate shall include wetting and compacting and the performance of all field and laboratory tests as specified. The unit rate shall also cover all additional costs of scarifying, harrowing, etc., where and when needed and trimming and smoothing of surfaces.

No additional payment shall be made in case of stockpiling of excavated materials and later rehandling of such material if directed by the Engineer in order to produce the specified embankment structure and the cost thereof shall be deemed to be included by the Contractor in his unit rates for the various items in the Bill of Quantities and shall not be paid for separately.

2.6 TOLERANCES OF FINISHED EARTHWORKS

All earthworks shall be finished to the dimensions and elevations shown on the Drawings. Unless otherwise specified, the following variations shall be acceptable:

- (a) Embankment width - not more than 20 cm over the specified widths and not more than 10 cm less than the specified widths. Embankment elevations - not more than 15 cm.

Channel width – The width shall not be exceeded the specified width more than 20cm,

- (b) Channel invert elevations – shall not exceed 5cm than the specified elevations,
- (c) Irregularities in surfaces of all earthworks - not more than 1.5 cm when checked by a straight edge.

3. CONCRETE WORKS

3.1 STANDARDS, GRADES, COMPOSITION AND TYPES

3.1.1 General

This division describes the quality of materials and workmanship of concrete and reinforced concrete works cast in situ in all parts of structures below or above ground in all site locations. The Specification shall apply to concrete prepared on site as well as ready mixed concrete and small precast concrete elements. Generally, it is based on CP 110 Part I 1972 and on BS 4881, 5328 and 5337. In case of discrepancy or contradiction, the requirements of this Specification shall rule over any standard.

3.1.2 Life Span of Concrete Structure

New works are to be designed for a life of 60 years.

3.1.3 Standards and Codes

The current ruling Standards and Codes of Practice, detailed below, are made by reference part of this Specification.

BS 12 Ordinary Portland Cement

BS 410, 1796 Test Sieves and Test Sieving

BS 882, 1201 Aggregates from Natural Sources

BS 1881 Methods of Testing Concrete

BS 1926 Ready-Mixed Concrete

BS 3148 Tests for Water for Making Concrete

BS 4027 Sulphate Resisting Portland Cement

BS 4449 Hot Rolled Steel Bars for the Reinforcement of Concrete

BS 4461 Cold Worked Steel Bars for the Reinforcement of Concrete

BS 4466 Bending Dimensions and Scheduling of Bars for the Reinforcement of Concrete (Plain round mild steel or high yield)

BS 4482 Hard Drawn Mild Steel Wire for the Reinforcement of Concrete

BS 4483 Steel Fabric for the Reinforcement of Concrete

BS 5075	Concrete Admixtures
BS 5135	Metal Arc Welding of Carbon and Carbon-Manganese Steels
BS 5328	Methods for Specifying Concrete Part 1 to Part 4
BS 8007	Design of Concrete Structures for Retaining Aqueous Liquids
BS 8102	Protection of Structures against Water from the Ground
BS 8110	CP 110 Part 1 and Part 2 Structural use of Concrete
ASTM Standard C309	Liquid Membrane Forming Compound for Curing Concrete
ASTM Standard C260	Air Entraining Admixtures for Concrete
ASTM D 1227	Emulsified Asphalt Used as a Protective Coating
ASTM C76,	Reinforced concrete culvert (Drainage pipes)
AASHTO M 170	Chemical Admixture for Concrete
ASTM C494/C494M	Batching, Mixing and Delivery of ready-mixed concrete

In case of discrepancy or contradiction, the requirements of this Specification shall overrule any standard.

3.1.4 Classification and Composition

Concrete of all grades shall consist of coarse and fine aggregate, cement, water and additives. Generally, the grades of concrete shall be detailed as described in the following table. However, other grades may be required in the Specification.

Table 2.1 Concrete grades and Classifications

Grade/Class of Concrete Per B.S. 5328	Characteristic Compressive Strength (Kg/cm ²)	Minimum Cement Content (Kg per m ³) of Ready Concrete	Characteristic use
C20	200	250	Blinding/Lean concrete
C25	250	300	Cyclopean concrete
C30	300	350	Reinforced concrete
C35	350	400	Reinforced concrete

The relationship between grade of the concrete and its characteristic strength shall be as given in BS 5328. The grade of concrete to be used in particular locations shall be as given in Table 2.2 unless noted otherwise on the Drawings.

Table 2.2 Concrete strength requirements

Location	Maximum Coarse Aggregate Size (mm)	Grade of Concrete (BS 5328)
Liquid Structures	20	C20P
Blinding concrete - Sulphate Condition	20	C20P
Substructures thickness less than 400 mm	50	C30D
Liquid retaining structures	50	C35D

In the above table suffix P means a prescribed mix, D means a designed mix and A means a design mix complying with the requirements of BS 8007.

The specific grades of concrete to be employed in the different structures or parts of structures shall be as shown on the Drawings or indicated in the Specification, Bill of Quantities. The quantity of cement in the ready concrete shall in no case be less than the minimum quantities detailed in the above table.

The Contractor shall have trial mixes for the various structures designed by an approved laboratory. The mixes shall be designed with the objective of producing concrete having suitable workability, density, impermeability and required strength.

Proportions shall be determined in accordance with the "Design of Normal Concrete Mixes" published by the United Kingdom Department of the Environment, or other approved methods, for the requirements set out in this Specifications.

The amount of water used in the concrete shall be changed as required to secure concrete of the proper consistency and to adjust for any variation in the moisture content or grading of the aggregates as they enter the mixer. Addition of water to compensate for stiffening of the concrete before placing will not be permitted. The mix to be used in every part of the Work shall be subject to the Engineer's approval and the Engineer shall have the right to demand the mix proportions and water-cement ratio to be changed during the progress of the work if in his opinion such changes shall be necessary to secure the required quality of the concrete as detailed above.

The mix proportions shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, having regard to the structural element being constructed, the disposition of reinforcement, and taking full account of the environment to which, it will be subjected.

The minimum cement contents and maximum water/cement ratios of designed mixes shall be as given in Table 2.3. In the event of sulphate exposure precautions requiring lower cement content than those required for normal conditions the latter requirements shall prevail.

Table 2.3 Minimum Cement contents - Normal Conditions

Type of Structural Element	Exposure Conditions (BS 8110)	Minimum Cement Content (kg/m³)			Maximum
		Maximum Aggregate Six			Water/Cement
		40 mm	20 mm	10 mm	Ratio
Liquid Retaining Structures, Shafts and Tunnel Linings	Severe	295	325	356	0.55
All Foundations and Buried Structures	Moderate	270	300	340	0.60

Additional requirements when exposed to sulphate conditions (all structural concrete)

Concentration of Sulphates		Type of Cement	Minimum Cement Content (kg/m3)			Maximum Water/Cement Ratio
In Soil	In Ground Water		Maximum Aggregate Size			
(Total SO ₃)	Parts per 100,000		40mm	20mm	10mm	
< 0.2	< 30	OPC	NORMAL CONDITIONS			
0.2 - 0.5	30 - 120	OPC	300	330	370	0.50
		SRPC	250	280	320	0.55
0.5 - 1.0	120 - 250	OPC	Not Permitted	330	370	-
		SRPC	300			0.50
1.0 - 2.0	250 - 500	OPC	Not Permitted	370	410	-
		SRPC	340			0.45
> 2.0	> 500	SRPC	Ditto but with protective coating			0.45

3.1.5 Types of Concrete**a) Ready-Mixed Concrete**

The use of ready-mixed concrete will be permitted provided the production, transportation, sampling, and testing of the ready-mixed concrete shall conform to the requirements of B.S. 1926 and that the concrete meets the requirements of this Specification as to strength, cement content, impermeability, and other properties. The methods and equipment used and the speed required for transporting concrete shall be such that concrete having the required

composition and consistency will be delivered into the work, without objectionable segregation, loss of slump, and delay.

The Contractor shall notify the Engineer of the supplier from whom he intends to purchase the ready-mixed concrete and shall obtain the Engineer's approval in writing of such supplier. Before the commencement of concrete production, the Engineer shall be given notice to enable him to check the composition and cement content of the concrete about to be produced at the supplier's plant. However, the Engineer's approval of the supplier and his inspection of the concrete production shall not relieve the Contractor of his sole responsibility for the quality concrete, and the Contractor shall make good any damage and shall indemnify the Employer against losses caused by concrete not meeting the requirements of the Specification. The Engineer may at any time and at his discretion prohibit the use of any ready-mixed concrete which in his opinion does not meet the requirements of the Specification, and in such an event the Contractor shall discontinue the use of such ready-mixed concrete and shall at no extra cost to the Employer supply concrete mixed on the site, or ready-mixed concrete from another source meeting the Engineer's approval.

b) Cast in-Situ concrete

Cast in-situ concrete, also referred to as poured-in-place concrete, is a construction technique wherein concrete is mixed, placed, and cured directly at the project site.

This following specification covers the supply, placement, compaction, curing, and testing of in-situ concrete for structural and non-structural elements, including slabs, footings and walls of channel and of manholes. And outline the technical requirements, material standards and specifications, execution procedures (placing, compaction and curing), and quality control measures (testing and quality control) necessary to ensure the safe and durable implementation of cast in-situ concrete elements.

Key considerations include:

- Selection of appropriate concrete grades and mix designs based on structural and environmental demands
- Proper formwork installation and reinforcement detailing to achieve dimensional accuracy and surface finish
- Controlled placement and compaction techniques to prevent segregation and ensure uniformity
- Systematic curing and testing protocols to verify strength development and long-term durability
- This specification serves as a reference to execute cast in-situ concrete works in accordance with best practices and contractual obligations. It also supports quality assurance efforts by defining inspection checkpoints, tolerances, and documentation requirements throughout the construction process.

c) Lean or Blinding Concrete

Lean and blinding Concrete shall be proportioned to 250 kg of cement per 1 m³.

Should such defect be found after the removal of formworks, the concerned parts shall be demolished and cast a new at the expense of the Contractor. The location of these types of concrete shall be indicated on the drawings. In all cases the Engineer must give his written approval for concreting.

3.2 MATERIALS FOR CONCRETE

3.2.1 Cement

Cement shall comply with one of the following:

- BS 12 (Ordinary Portland cement).
- BS 4027 (Sulphate resisting Portland cement).

The Concrete Cement used for Concrete Structure in contact with wastewater, water and soil shall be Sulphate resisting Portland Cement and in accordance with BS 4027.

Consignments of any cement shall be used in the order in which they are received. Any cement stored on the site over three months may be rejected by the Engineer. Should the quality of the cement be adversely affected by dampness or any other cause the cement shall be removed from the site. Storage will be in dry and weatherproof conditions.

Each shipment of cement shall be stored so that it may readily be distinguished from other shipments. The cement shall be free form lumps and shall be otherwise undamaged when used in concrete.

Sacked cement shall be delivered to the Site in the sound original bags of the manufacturer and shall be stored in a watertight and weatherproof shed on a floor raised at least 15 cm from the ground. Stacking cement bags to excessive heights they may cause damage to cement or is otherwise undesirable, as determined by the Engineer, will not be permitted.

Bulk cement shall be stored in weatherproof bins or silos to be approved by the Engineer. The bins shall be emptied and cleaned at reasonable intervals as directed by the Engineer.

The quality of each consignment of cement shall be verified by manufacturers' certificates showing the results of tests, as per B.S.12, appropriate for cement to be used in tropical climates. Where the Engineer so orders, the Contractor shall perform at his own cost additional tests on samples selected by the Engineer, all in accordance with B.S.12.

Reinforced and mass concrete must be vibrated. Cement used for structures in contact with wastewater, soil and buried surfaces in contact with underground water shall be sulfate resisting Portland cement (BS 4027). Cement for all other structures shall be ordinary Portland Cement (BS12).

Admixtures and mix design of the different Grades of concrete shall be submitted for approval prior to commencing the work.

3.2.2 Water

The water used for mixing concrete shall be of potable quality, free from harmful materials, organic and salts, such as clay, loam, acids or trade effluent. River water may be used after its suitability is ascertained beyond doubt by tests according to B.S. 3148. Periodic tests shall be carried out to keep a continuous check on the suitability of such water. The source of the water shall be subject to the Engineer's approval.

3.2.3 Admixtures

Usually, the waterproof concrete specifications are written aiming to achieve a watertight concrete structure.

But practically the concrete can sometime be very difficult to place.

If agreed by the Engineer, the contractor will be permitted to use concrete with more plastic consistency helping to produce a smoother and denser floor and wall finishes requirements.

In heavy reinforced structures, a good and long workability is also important.

It is impossible to meet the water/cement ratio > 0.5 and a good workability requirement at the same time unless concrete admixtures are used.

Contractor may use admixtures and shall use if required by the Engineer admixtures such as:

- 1 Retarder
- 2 Accelerator
- 3 Plasticizer or super plasticizer air entraining agent
- 4 water proofing admixtures Fluid admixtures
- 5 Anti-freeze admixtures

Plasticizer and super plasticizer give good workability and correct consistency (even for pumped concrete with extended working times) to enable the concrete to be compacted as fully as possible in as short a time as possible with a high reduction in the water/cement ratio.

a) Retarder (ASTM C494/C494M)

By the use of suitable retarder, the Contractor must obtain that the start of the setting process be delayed from a few hours to a day or more.

This will permit to fresh concrete to be poured and vibrated over longer periods of time.

The controlled retardation of the initial set, must not be in no way slow down the subsequent hardening process.

The period of time during which the concrete can still be vibrated is known as the retardation time.

The choice of retarder dosage will be made by referring to the dosage chart of the furnisher, preliminary trials may be asked by the Engineer to ascertain the correct dosage for planned retardation.

Dosage can vary with the type of structure (foundation slab or walls...) and with temperature (ambient air and/or concrete) the Contractor must consult with the Engineer to either avoid construction joints (cold joints) or to work out a concreting schedule where entire mass of concrete is required to set simultaneously.

b) Water proofing concrete admixture (ASTM C494/C494M)

A concrete admixture in liquid or powder form can be used by the Contractor as highly efficient water proofing principal agent with a secondary function as plasticizer.

The dosage will correspond to % of the weight of cement. The admixture must be compatible with the type of cement.

The admixture will be dispensed directly into the mixing water (liquid admixture) prior to its

addition to the aggregates /or/ added directly to the dry mixed aggregates.

c) Other Admixtures

The Contractor will relate to the technical specifications of the admixtures Supplier. Admixtures that contain chlorine will be forbidden.

Admixtures used shall be furnished by the Contractor and the cost of the materials and all costs incidental to their use shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately.

3.2.4 Aggregates

Fine and coarse aggregates shall be as defined by and be of the quality and nature required by BS 882 and BS 1201 whichever is applicable. In addition, they shall be chemically inert to alkali reaction.

Prior to acceptance of an aggregate as inert to alkali reaction the report of a qualified geologist, appointed by the Engineer on the suitability or otherwise of materials shall be obtained following examination of all types of material that the proposed sources will yield during the course of the contract. The Engineer may require that samples be taken from boreholes and for large contracts or contracts extending over a long period then more than one report is to be obtained.

a) General:

Aggregates for concrete shall be fine aggregate and coarse aggregate and shall be supplied by the contractor from approved sources, but the approval of any source by the Engineer shall not be construed as approval of all materials taken from that source, and the Contractor will be held responsible for the specified

quality of all materials used in the work and for their being equal to the approved samples.

The Engineer, at the Contractor's expense, will test the aggregates and the Contractor shall provide such facilities as may be necessary for procuring representative test samples. The Contractor shall submit, for preliminary tests and approval, representative samples of 100 kg each of fine aggregate and of each size of coarse aggregate proposed for use in the work at least 30 days before the aggregates are required for use.

Should the Engineer reject any sample furnished by the Contractor, the Contractor shall immediately supply a sample or samples from some other source until all samples are approved by the Engineer.

Those samples which have been finally approved by the Engineer as meeting the requirements of the Specification shall be kept on the Site until the completion of all concrete work and all aggregates brought to the Site shall be compared with such approved samples.

Any aggregate rejected by the Engineer shall be immediately removed from the Site, unless the Engineer shall permit its use after undergoing further treatment by washing and or screening in order to bring it up to standard.

The aggregates shall be brought to the Site in separate loads, each containing aggregates of one size. The aggregates shall be stored in such a way as to prevent aggregates of different sizes from being mixed together in storage. Aggregates mixed either in transport or on Site will be rejected.

b) Fine Aggregate:

Fine aggregate for concrete shall be natural sand (but not beach sand) or a mixture of natural sand and fine crushed stone. It shall meet the requirements of B.S. 882 and its grading shall be within the limits of one of grading zones 1, 2 or 3 given in Table 2 of B.S.882. In addition, it shall have a specific gravity of not less than 2.5, shall not contain more than 5 percent by volume of shells or shell fragments. The fine aggregate delivered to the batching plant shall have a uniform and stable moisture content.

When necessary, or when required by the Engineer, all fine aggregate shall be washed in clean water, before being incorporated in the Works.

c) Coarse Aggregate:

The coarse aggregate for concrete shall be natural gravel or crushed stone. It shall consist of hard, dense, durable uncoated rock fragments and shall meet the requirements of B.S.

882.

Coarse aggregate for reinforced concrete shall be either graded aggregate or made up of a number of single size aggregates, with the largest particles not exceeding the following sizes:

(a) 40mm, or

- (b) $1/3$ of the smallest thickness of concrete members, or
- (c) $3/4$ of the smallest space between reinforcement bars, whichever is the smallest. Coarse aggregate for non-reinforced concrete may contain particles up to 3"

The grading of coarse shall lie within the limits given in Table 1 of B.S. 882. The exact sizes of the coarse aggregate and the grading to be used shall be determined as part of the mix design.

All aggregates shall be approved by the Engineer.

3.3 BATCHING AND MIXING IN ACCORDANCE TO ASTM C94

3.3.1 Batching

The Contractor shall provide equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. For concrete Class C20P and higher, the amounts of sand, bulk cement and each size of coarse aggregate entering each batch of concrete shall be determined by weighing, and the amount of water shall be determined by weighing or volumetric measurement. Where sacked cement is used, the amount of cement entering the mixture shall be determined on the basis of integral sacks of cement and the use of cement from torn bags shall not be permitted.

Where batching by volume is permitted by the Engineer, only precisely dimensioned gauge boxes approved by the Engineer shall be used for the sand and different sizes of aggregates. After filling the box, the aggregate shall be struck off level with the brim. Sand shall be poured or shoveled into the gauge boxes without compacting. All gauge boxes shall bear marks in red oil paint showing the kind and size of aggregate for which each box is to be used. No boxes similar in shape and appearance but different in volume from the approved gauge boxes shall be kept on the Site.

3.3.2 Mixing

The materials shall, unless otherwise directed by the Engineer, be mixed in approved mechanical batch mixers. In each case, the number and capacity of mixers employed shall be sufficient for the concreting operations being undertaken, shall allow for sufficient reserve capacity at all times and shall be subject to the approval of the Engineer.

The mixing shall continue until there is a uniform distribution of the materials and the mass is uniform in color and consistency, but in no case shall the mixing be for less than 2 minutes after all the ingredients are in the mixer. Water shall be added prior to, during and following the mixer- charging operations. Overmixing requiring the addition of water to preserve the required concrete consistency will not be permitted.

No dry material shall be introduced into a mixer until all material from the previous batch has been removed and the interior of the mixing drum has been cleaned of encrustations of concrete or mortar. Remixing of concrete or the addition of water to a mixture that has already begun to set or that is otherwise unsuitable for casting shall not be permitted and such concrete shall be wasted. When a concrete mixer has been out of use for more than 20 minutes, or when the type of cement is changed, the mixer shall be thoroughly cleaned before a fresh batch of concrete is made in it.

The Engineer may in exceptional cases permit hand mixing of lean and other non-reinforced concrete. No hand mixing shall be done unless authorized in writing by the Engineer. The batches in hand mixing shall not exceed $1/6$ of a m³. Hand mixed concrete shall not be used until the mixing of the whole batch has been completed and the concrete is of uniform color and consistency. Hand mixing shall be done twice on dry aggregate, and at least twice wet, on a clean and even surface, which will prevent the loss of water during mixing. The water added shall be measured in order to prevent the use of an excessive quantity of water.

When mixing by hand, the quantity of cement shall be increased by 10% above that specified in previous Section.

3.4 PLACING AND CURING

3.4.1 Preparations for Placing

No concrete shall be placed until the Engineer has approved the formwork and reinforcement. The Contractor shall give at least 48 hours' notice to the Engineer of the times he proposes to concrete and no concreting shall take place unless either the Engineer or his Representative is present.

Concrete shall be placed only in the presence of the Engineer or his duly authorized Representative, unless written permission has been given by the Engineer to place concrete without himself being present or represented. The Contractor shall give the Engineer not less than 48 hours' notice before the day on which he intends to commence placement of concrete in any structure or substantial part thereof.

No concrete shall be placed until all reinforcement, formwork, parts to be embedded, and preparation of surfaces involved in the placing have been approved.

All surfaces of forms and embedded materials shall be clean and free from dried mortar which may have encrusted them from previously placed concrete.

All surfaces of foundations and areas upon or against which concrete is to be placed shall be free from standing water (except for concrete required to be placed under water), mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments. Absorptive surfaces shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete. On surfaces of rock upon or against which concrete is to be placed, a 2 cm layer of 1:3 cement mortar shall be spread immediately prior to placing concrete and shall be well worked into the surface with the aid of brushes. Care shall be taken

that the mortar does in no case set before concrete is placed on it. The cost of such mortar and its spreading shall be deemed to be included in the rates for concrete.

3.4.2 Placing

Concrete shall be deposited as far as practicable directly in its final position and shall not be placed in a manner permitting or causing segregation. The Contractor shall provide suitable openings in the formwork and/or drop chutes and baffles to confirm and control the falling of concrete, and to limit its free drop to a maximum of 1.50 meters.

Except as intersected by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which shall not exceed 60 cm, in such a manner that no layer of concrete will begin setting before the next layer is placed on top of it. In no case shall the delay between the placing of any two adjacent layers be such that the vibrating unit will not readily penetrate of its own weight the concrete placed before the delay.

Concreting shall be carried out continuously between and up to joints, the position and arrangement of which shall be predetermined and no interruption of placing other than at these joints will be permitted. To this end, the Contractor shall take all necessary measures, such as preparing a sufficient stock of materials, stand-by equipment, shift-work, lighting for night-work, etc.

In the event of unavoidable stoppage in positions not predetermined, the concrete shall be terminated on horizontal planes and against vertical surfaces and construction joints. Where required the Contractor shall also provide keyways, dowels, and/or water stops to ensure a perfect bond and/or watertightness at the joint.

Where the concrete abuts against earth or any other material liable to become loose, the greatest possible care shall be taken to avoid falls or run of such or other materials upon the surface of the concrete, and if any such falls or runs occur the surface of the work soiled thereby shall be removed until a new and clean surface shall have been obtained, and all spaces left by such falls or runs beyond the prescribed dimensions of the work, or caused by the negligence or for the convenience of the Contractor, shall be built up with concrete at the dimensions of the work, or caused by the negligence or for the convenience of the Contractor, shall be built up with concrete at the discretion of the Engineer, and the additional cost so incurred shall be held to be included in the Contractor's rates in the Bill of Quantities for work within the original Contract limits.

No concrete shall be placed in water, except with the written permission of the Engineer, and the method of depositing the concrete shall be subject to his approval. Concrete shall not be placed in running water and shall not be subjected to the action of running water until after the concrete has hardened.

Surfaces of rock upon or against which concrete is to be placed, shall be prepared and cleaned as specified and placing of concrete shall be carried out as detailed below for construction joints. No concrete shall be placed when the

ambient temperature at the time of placing and/or 2 hours thereafter is expected to be below 4oC. The temperature of the concrete when being placed shall not exceed 32oC.

In hot weather when the temperature of the concrete is liable, in the opinion of the Engineer, to rise above 32oC, the Contractor shall, at his own expense, employ effective means, to the satisfaction of the Engineer, for reducing the temperature in the mix, such as sprinkling of water on the aggregate, protection of the water lines from the sun, painting of mixers and water tanks with light-reflecting paint and/or placing them in shadow, or by adding crushed ice to the water in a proportion not exceeding 50% of the water. The addition of ice will be permitted only if it has been proved to the satisfaction of the Engineer's Representative that all other means for the reduction of temperature are insufficient.

a) Hot weather concreting

Heat accelerates the hydration reaction of cements; thus, it increases the heat of hydration and accordingly, shrinkage and cracks are likely to occur. It is necessary to abide by the following measures:

- Use concrete as compact as possible.
- Use cement of low heat of hydration.
- Reduce the cement dosage as far as practicable according to the requested characteristics of concrete.
- Use a water reducing plasticizer in order to reduce the quantity of mixing water (0.5 to 0.75 in weight of cement).
- Use a setting retarder which increases the heat of hydration time.
- Cool concrete constituents. This is an expensive method, but gives the best results.
- moisturize the hardened concrete on which fresh concrete shall be placed in order to avoid loss of water.
- Cover the structures after concreting, in order to prevent water evaporation from fresh concrete.
- Use Antisol-E which protects concrete from desiccation (suppress the use of damp coverings, watering, etc...).

b) Cold weather concreting

When concreting in cold weather, and in order to prevent having a frozen and porous concrete, plasticizers and water reducing admixtures shall be used to reduce the quantity of mixing water, while preserving the workability of fresh concrete at an acceptable degree.

Low temperature slows down the reaction of hydration of cement and therefore, delays formworks removal. The following precautions shall be taken:

- Use a quick setting cement
- Increase the C/W ratio (plasticizer - water reducer)
- Heat the materials (water + aggregates). However, the temperature of concrete shall not exceed 30oC.
- Use isolating formworks (wood, panels coated with expanded polystyrene, etc.)
- Protect fresh concrete with thick dry covers.
- Heat concrete eventually (hot formworks).
- Use antifrost products (1% in weight of cement).

No concrete shall be placed when the ambient temperature is -0oC.

Placing concrete at a temperature below + 5oC is allowed provided that the above-mentioned precautions are respected and upon the prior approval of the Engineer.

3.4.3 Consolidation of Concrete (Vibration)

Each layer of concrete shall be consolidated to the maximum practicable density, so that it is free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded materials.

All concrete Class C20P and higher shall be consolidated by power- driven immersion (“needle”) type vibrators having a frequency of not less than 9000 oscillations per minute. The vibrators shall be inserted into the concrete at intervals not exceeding 50 cm and shall be allowed to penetrate and re-vibrate the concrete in the upper portion of the underlying layer.

On slabs not exceeding 25 cm in thickness the use of flat surface tamping vibrators with a frequency of not less than 5000 oscillations per minute will be permitted, provided that it is supplemented by immersion vibrators adjacent to the forms and to concentrations of reinforcement bars.

On walls not exceeding 20 cm in thickness external vibrators, fixed to the forms, will be permitted. External vibrators shall be raised in lifts as the filling of the forms proceeds each lift being not more than the height of concrete visibly affected by the vibration. They shall be placed horizontally, at distances not greater apart than the radius through which the concrete is visibly affected.

The types, sizes and numbers of vibrators shall be subject to the approval of the Engineer.

At least one stand-by unit of each vibrator type and ample spare parts for all types employed shall be available on Site during placing of concrete to ensure continuous placing with no stoppage due to breakdowns.

The vibrators shall be applied in each position for as long as required for the concrete to become uniformly plastic and shall be withdrawn as soon as water appears on the surface. Systematic spacing of insertion of the vibrators in the concrete shall be established to ensure that no concrete remains un-vibrated.

Care shall be exercised to avoid contact of the vibrating heads with the surfaces of the forms and the reinforcing bars or other embedded material. The vibration shall everywhere be supplemented by hand spading. Vibration shall never be used to cause concrete to flow in a lateral direction, as this will lead to segregation.

The cost of all consolidation shall be deemed to be included in the Contractor's rates for concrete.

3.4.4 Finishing of Concrete Surfaces

Formed concrete surfaces, i.e. surfaces cast against forms, shall receive the required smoothness and texture by the use of appropriate forms. After removal of forms and the specified curing all fins and offsets caused by misaligned or defective form boarding shall be removed. Tie wires shall be cut back to at least 15 mm below the concrete surface and the resulting depressions as well as the holes left after the removal of tie rod fasteners shall be filled with non-shrinking cement mortar and finished flush with the surrounding areas.

Where the concrete surfaces will be permanently exposed to view, the ground and filled areas shall have the same color, texture and degree of smoothness as the surrounding concrete surfaces. Honeycombed areas and other major defects in concrete shall be repaired, and the repaired areas given the required finish.

Unformed concrete surfaces that are to be covered shall require no other finishing than sufficient levelling and screeding to produce an even uniform surface. Unformed concrete surfaces that are to remain permanently exposed shall be given a floated surface, unless a trowelled finish as described below is required. Floated finish shall consist of levelling and screeding to even and uniform surfaces followed by floating without the addition of any topping as soon as the screeded surface has stiffened sufficiently. Floating shall be done to the minimum required to produce a surface that is free from screed marks and is uniform in texture. The finish shall be given a final touch-up with a wooden float at an appropriate time after completion of the initial floating.

Trowel finish shall be applied to uniformed concrete surfaces that will be in contact with liquids and elsewhere as shown on the Drawings or ordered by the Engineer. When the surface screeded and floated as described above has hardened sufficiently to prevent excess of fine material to be drawn to the surface, steel trowelling shall be started. Steel trowelling shall be performed with firm pressure, such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Where required, trowelling shall be done with the addition of a certain amount of cement as specified in the Specification or Bill of Quantities.

Unless otherwise specified or shown on the Drawings, all exterior angles shall be chamfered to the approval of the Engineer. The cost of Floated Finish, Trowel Finish and Chamfers shall be deemed to be included in the unit rates for concrete work and shall not be paid for separately.

3.4.5 Curing of Concrete

From casting until the end of the specified minimum curing period, the concrete shall be kept constantly moist and adequately protected against damage due to fluctuation in surface temperatures. Immediately after casting, the exposed surface of the concrete shall be covered to prevent drying and to minimize temperature variations, until the commencement of curing at an age of not more than 20 hours. Curing of formed surfaces shall commence as soon as the formwork is removed. During curing the concrete shall be kept suitably moist by:

- Direct application of water at ambient temperature, e.g. by spray or by ponding, or,
- Covering with absorptive material, e.g. sand or hessian, kept constantly damp. Ventilation of any gap between the material and the concrete should be prevented so as to maintain near saturated conditions in the air within the gap, or
- When specifically permitted in writing by the Engineer, by sealing the surface of the concrete, before it has lost any of its original water by evaporation, by means of a sealing membrane which will effectively prevent any loss of water from the concrete. The sealing compound shall be white-pigmented and shall conform to Standard Specification for Liquid Membrane forming Compound for Curing Concrete, ASTM Designation C309 latest edition, or to another standard acceptable to the Engineer. The type and make of sealing compound and its form of application and use shall be subject to the approval of the Engineer. Membrane curing shall not be used on surfaces upon or against which concrete is to be cast or which are to be plastered or painted.

The cost of curing shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately.

3.4.6 Methods of Measurement and Payment

This activity will be paid by linear meter of channel, or by the volume of the concrete, measured in m³ after vibration and acceptable Laboratory testing result, as specified in the Bill of Quantities.

Payment: The unit rate shall be the full compensation for labour, tools, equipment, materials and any other incidentals that may be required in carrying out the work for this item.

This activity includes the cost of the formwork (fair-faced concrete), vibrating the concrete during the pouring to avoid the segregation, removal formworks, curing as directed by the engineer.

3.5 CONSTRUCTION AND EXPANSION JOINTS

3.5.1 Construction Joints

The position of construction joints will be as specified in the drawings or as requested by the Engineer. If there is a need on site to revise any specified position /or/ to have additional construction joints the proposed positions should be agreed with the Engineer.

Full structural continuity must be assumed in design at a construction joint. Reinforcement will be fully continuous across the joint, and the concrete is taken to be as nearly monolithic as possible. The concrete at the joints should be bonded with the one subsequently placed against it, without provision for relative movement between the two.

Concrete should not be allowed to run to a feather edge, and vertical joints should be formed against a stop end. Particular care should be taken when framing the joint.

The surface of the first pour should be roughened to increase the bond strength and to provide aggregate interlock.

With horizontal joints, the joint surface should be roughened without disturbing the coarse aggregate particles, by spraying the joint surface approximately 2h to 4h after the concrete is placed, with a fine spray water and/or brushing with stiff brush.

Vertical joints can be treated similarly, if the use of a retarder on the top is authorized, to enable the joint surface to be treated after the stop end has been removed.

If the joint surface is not roughened until the concrete has hardened, the larger aggregate particles near the surface should be exposed by sand blasting or by applying a scaling hammer or other mechanical advice.

Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against the old one. It may need to be dampened prior to the new concrete being placed, to prevent excessive loss of mix water into it by absorption.

Particular care should be taken in placing of new concrete close to the joint to ensure that it has adequate fines content and is fully compacted and dense.

N.B. When instructed by the Engineer in designing construction joints for retaining aqueous liquids it is necessary to incorporate water-stops in properly constructed joints.

Construction joints shall be formed only in the positions shown in the drawings or indicated by the Engineer and concreting shall be carried out continuously between and up to joints.

All intersections of construction joints, permanently exposed, shall be made absolutely straight and level or plumb and matching with adjacent members.

Construction joint shall be formed at right angles to the axis of the member concerned, by the insertion of rigid stopping-off forms in the case of horizontal or inclined members.

The upper surface of lifts of concrete in walls and columns shall be horizontal.

The surface of the stopping-off form /or/ the horizontal surface shall be indented to produce a key the old and new work.

The face of the horizontal joints brushed and roughened shall be rendered with a 1.0 to 1.5 cm thick layer of cement-sand mortar having the same relative proportions of cement and sand (without coarse aggregate) and the same water-cement ratio as the concrete to be placed upon it, and the new concrete shall then be laid immediately upon it and thoroughly punned in.

Where joints will be permanently visible, the mortar shall be kept back at least 25mm from the exposed face.

In the case of vertical joint, the face shall be rendered with a coat of neat cement placed immediately before each fresh lift of new concrete.

NB: No Day Joints /or/ Stopping-off joints will be permitted in water retaining structures.

Pouring operations shall be continuous between joints as shown in the drawings.

The Contractor shall have sufficient materials and standby equipment to meet these requirements.

Where due to accident or breakdown it is impossible to continue concreting, the Engineer /or/ his Representative shall be immediately notified and his verbal instructions which shall be confirmed in writing as soon as possible, regarding either the making of a construction joint /or/ the taking out of new concrete back to the last construction joints, shall be complied with immediately.

3.5.2 Expansion Joints

For concrete structures retaining aqueous liquid, all eventual expansion joints are designed to accommodate repeated movement of the structure without loss of liquid.

The joint is designed to suit the characteristics of the material available and should also provide for the exclusion of grit and debris that would prevent the closing of the joint.

Detailing of places where the joint changes direction /or/ intersects with another joint should be uncomplicated.

At an expansion joint the Contractor shall provide a complete discontinuity in both reinforcement and concrete.

An initial gap should be provided between adjoining parts of the structure to accommodate the expansion /or/ contraction of the structure.

Waterstop, joint fillers and joint sealing compounds are essential.

3.5.3 The Joint Filler

An elastic joint filler material cut in sheets of the thickness specified and/or shown on the drawings, shall be:

- either placed in the forms before the first placed concrete is cast.
- or, may be attached to the first placed concrete surface means approved by the Engineer.

The elastic filler materials shall be of a quality approved by the Engineer and shall conform to US Federal Specification H-H-F-341a, or to a similar approved standard.

Where the exposed sides of the joint are filled with an elastic joint sealant approved by the Engineer, sheets of foamed polystyrene may be substituted for the above-described elastic filler.

The sheet of filler material, shall be cut to fit the entire contact surfaces of the complete side of the joint.

Where a water-stop is installed in the joint, the filler materials shall be placed on both sides of the water-stop so as to fit snugly about the bulb of the water-stop.

Except where a groove for joint sealant is to be formed, the edges of the filler materials shall be placed flush with the finished surface of the concrete /or/ the bottom of the chamfers.

Joints in the filler shall be made tight so that mortar from the concrete will not seep through to the opposite concrete surface.

N.B.: Joint sealing compound cannot be expected to provide a liquid-tight seal for more than a proportion of the life of the structure and water-stops should always be provided in movement joints by the Contractor and installation must follow the recommendations of the manufacturer.

3.5.4 Elastic Joint Sealant

Where shown in the Drawings, the groove formed on the exposed side of contraction or expansion joints shall be filled with an elastic joint sealant meeting the requirements of ASTM Designation D- 1850. The joint sealant is supplied in two components, base and accelerator, which are mixed together only immediately before use. Flow type sealant shall be used on horizontal or nearly horizontal surfaces, and heavy type on inclined and vertical surfaces. If required by the manufacturer, a suitable primer shall be applied on the joint surfaces prior to the filling of the groove and the time elapsing between the application of the

primer and the placing of the joint sealant shall not exceed the maximum prescribed by the manufacturer. Care shall be taken that the mixed compound is used before the expiry of its pot-life as indicated by the manufacturer.

3.5.5 Payment for Joints

Unless specific items are included in the Bill of Quantities, the cost of all work and materials for making construction, contraction and expansion joints shall be deemed to be included in the rates for the concrete work and shall not be paid for separately.

3.6 REPAIR OF CONCRETE

3.6.1 General

Repair of concrete, where permitted by the Engineer shall be performed. The Contractor shall correct all imperfections on the concrete to the satisfaction of the Engineer.

3.6.2 Concrete Repairs in New Concrete Works

Any concrete which in the opinion of the Engineer fails to comply entirely with this specification shall be declared defective and shall be cut out, removed from the site and replaced, and any steelwork reinforcement or other material damaged by the cutting and shall be replaced, all at the Contractor expansion.

The Contractor will submit to the Engineer, details of his proposal for rectifying the defects, and shall comply with the Engineer's instructions, regarding the procedure of carrying out the work.

Notwithstanding the Engineer approval, should the remedial work prove unsatisfactory, the Contractor shall make good the work and bear the whole cost occasioned by the defective work.

Immediately after the forms have been removed, all fins and projections and all timber work at joints shall be removed and rubbed smooth with a carborundum block.

All holes and honeycombing in the surface shall be cleaned out and roughened up to give a good key. These holes shall then be filled with 1:2 cement/sand mortar and after it has thoroughly hardened, the surface shall be rubbed down with a carborundum stone to an even finish.

Concrete filling shall be used for holes extending entirely through the concrete, for holes in which no reinforcement is encountered, and which are greater than 0.20 m² and deeper than 10 cm and for holes with reinforcement concrete which are in area greater than 0.05 m² and which extend beyond reinforcement.

Plastering of smooth concrete surfaces will not be permitted.

All mortar and concrete filling must be non-shrinkable and shall be kept constantly moist and protected from drying due to surface temperature and natural ventilation.

All materials, procedures and operations used in the repair of concrete shall be subject to the Engineer direction. All fillings shall be bonded tightly to the surface of the holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been cured and dried.

All repairs of concrete executed by the Contractor shall be deemed to be included in the unit rates for concrete work in the Bill of Quantities and shall not be paid separately.

3.7 TESTING OF CONCRETE

3.7.1 General

Prior to the commencement of work, trial mixes shall be prepared and preliminary tests for workability, compressive strength and impermeability (where required) will be made at an authorized laboratory. The results of these tests will be used in specifying the mix design to be used by the Contractor. During the progress of work, daily slump tests will be made to ensure that the concrete is dense and of an adequate workability.

With the commencement of concrete placement and on each day concreting, samples shall be taken for testing for compressive strength at the ages and frequencies as prescribed hereafter. Where required, samples shall be taken for impermeability tests. The Engineer shall determine the elements from which concrete samples shall be taken for testing.

3.7.2 Slump Tests

The slump measured in accordance with B.S. 1881 shall not exceed 5 cm in concrete for foundations and horizontal or inclined slabs and shall not exceed 10 cm in other parts of the structures, unless otherwise specified or directed by the Engineer. Slump tests shall be made as directed by the Engineer, at a minimum of 1 slump test per batch of less than 8 m³.

3.7.3 Compressive Strength Tests

For testing the compressive strength of concrete, samples of fresh concrete shall be taken and used for preparing test cubes. The cubes shall be tested for compressive strength after 7 days and 28 days. The dimensions of the cubes and the methods of sampling and testing shall be in accordance with B.S. 1881. The cubes shall be marked and dispatched to the laboratory according to the instructions of the Engineer and at such intervals as may be specified by him.

Unless otherwise specified or directed by the Engineer, at least three samples shall be taken from different batches on the same day of casting. Out of every sample, at least two test cubes shall be prepared for testing at 7 and 28 days, respectively. The number of samples taken from hardened concrete which for any reason was not taken while the concrete was fresh or of which the strength obtained did not meet the requirements, and taking and testing of such samples shall be in accordance with B.S. 1881.

The average strength of the cubes or more tested at each age may be taken as the works cube strength of the concrete. This works cube strength may be accepted as complying with the specified requirement for works cube strength, if none of

the compressive strengths of any of the cubes is below the specified works cube strength, or if the average strength is not less than the specified works cube strength and the strength of the weakest cube is not less than that listed in the following table. The table details the required cube strengths of work cubes and trial mixes for the various grades of concrete.

Compressive Strength Requirements (for all types of Concrete)

Grade	Characteristics compressive strength (kg/cm ²)	Cube strength at 28 days (kg/cm ²) **	
		Works cubes *	
		Average	Weakest Cube
C20	200	275	170
C25	250	325	213
C30	300	375	255
C40	400	475	340

*Strength requirements may be adjusted in accordance with CP110, if and as detailed in the Specification.

If for any part of a structure the works cube strength does not reach the required values at the age of 28 days, or if the concrete has hardened and samples have not been taken while the concrete was still fresh, the Engineer may permit the cutting of at least six cylinders out of the same part of the structure, and the cylinders shall be tested in accordance with the requirements of B.S. 1881. The concrete shall be deemed to comply with the specification if its strength, as deduced from the cylinder tests, meets the compressive strength requirements detailed in the above table and the results of the previous samples shall not be taken into account. Should the concrete also fail to meet the requirements in the testing of the cylinders as above, all the concrete from which the samples have been tested will be considered defective. In such a case, the Engineer may at his own sole discretion, order the carrying out of additional tests by any method he may deem fit, and if such additional tests show the concrete meeting the requirements, he may accept it. Should the concrete not meet the strength requirements in the test of samples as above, or in the additional tests that the Engineer may have permitted, then it shall be dealt with according to one of the following two methods, chosen at the sole discretion of the Engineer.

- The Contractor shall demolish and re-construct the part of the structure made of the defective concrete.
- The Engineer will accept the defective concrete but reduce its price as defined hereinafter. This provision shall apply only to concrete in which the average compressive strength of the samples taken is not less than the Characteristic Compressive Strength listed in the table. In such an event, the Engineer may accept the concrete, but reduce 2% of the unit rate per cubic meter of the defective concrete for every kg/cm² of the

difference between the required strength and the average strength. (For example: C130 concrete was required. The strengths of all samples were above 255 kg/cm² but the average strength of the samples was 367.5 kg/cm² instead of 375 kg/cm². In this case the Engineer may, at his sole discretion, accept the concrete and reduce its unit rate by 15%).

Concrete that has not met the requirements as stated above and concrete that the average compressive strength of the samples of which is below the nominal strength shall be rejected in every case. The part of the structure made of the rejected concrete shall be demolished and re- built by the Contractor at his own cost.

3.7.4 Impermeability Tests

Where required on the Drawings or the Specification, or where directed by the Engineer, the concrete shall be tested for impermeability. Samples for the impermeability tests shall be in the form of 20x12 cm plates and shall be prepared, cured and tested in accordance with DIN 1048. Unless otherwise stated in the Specification or elsewhere in the Contract, the requirement for impermeability shall be that, when a water pressure of 2 kg/cm² is applied to one side of the test specimen, no moisture shall appear on the other side.

3.7.5 Payment for Tests

The costs of sampling and performing the tests in accordance with this Section, including all labour, equipment, transportation and ancillary works, shall be deemed to be included by the Contractor in his unit rates for concrete and shall not be paid for separately, unless specific items for testing are included in the Bill of Quantities.

3.8 STEEL REINFORCEMENT

3.8.1 General

Reinforcement steel for concrete shall meet the requirements of the relevant British Standards listed in this Specification.

The Contractor shall supply the Engineer with certificates from the makers of the steel showing that it has complied under test with the appropriate Standard Specification, stating the process of manufacture and if required the chemical analysis, and such test sheets shall be forwarded to the Engineer one week before the dispatch of such steel to the Works.

The steel shall be stored off the ground and kept scrupulously clean and free from loose mill scale, loose rust, oil and grease or other harmful matter. Any bar

adversely affected by storage or for any other reason shall be cleaned or removed from the Site and replaced by the Contractor at his own expense.

3.8.2 Bar Schedules

Where reinforcement bar schedules are shown on the Drawings to assist the Contractor in preparing and placing the steel reinforcement, the Contractor shall carefully check such bar schedules for compliance with the structural drawings and shall correct the bar schedules as necessary. Where no bar schedules are incorporated in the Drawings, the Contractor shall prepare such schedules at his own cost and responsibility. In any case, the Contractor will be solely responsible for the correct preparation and placing of steel reinforcement in accordance with the Drawings. Any bars bent and prepared according to incorrect schedules, and not suitable for placing in the structure will be rejected and will not be paid for.

3.8.3 Bending Reinforcement

All bending shall be done cold, by an approved bending machine, in a manner that will not injure the material. Welded joints shall not be permitted in any bar. Only experienced steel benders, to the approval of the Engineer, shall be employed in bending. All bending shall be in accordance with British Standard 4466. The internal radius of all cranks and bends shall be at least three times the diameter of the bar. Heating of mild steel bars only to facilitate bending, especially of large diameter bars, will be permitted, provided the temperature of the steel does not exceed

850°C (cherry-red heat) and provided further that the cooling rate is low and uniform (normal still- air cooling). Quenching of hot-bent bars in water will not be permitted. Reinforcement bars depending on cold working for their strength, such as cold drawn or twisted bars shall not be bent hot.

3.8.4 Placing Reinforcement

No pieces of metal or blocks or wood shall be used on the bottom surface or against the sides of formwork to keep the reinforcing bars in position. For this purpose, specially prepared precast concrete blocks shall be used of a thickness equal to the concrete cover specified hereafter. The use of plastic spacers is also accepted.

Unless otherwise shown on the Drawings or directed by the Engineer, the cover reinforcement, including cover stirrups and distribution bars, shall be at least equal to the diameter of the principal reinforcement bars plus

- at least 1 cm in the case of solid interior slabs, or at least 1.5 cm in all other cases, or
- at least 1 cm in addition to the above in the case of elements exposed to climatic influences.

In any case, all parts of a structure in direct contact with the earth or water shall have at least 3 cm cover over reinforcement, including stirrups and distribution bars.

The minimum cover stipulated above shall be increased, if necessary, up to 5 cm wherever a structure is particularly liable to danger of corrosion or abrasion, and up to 8 cm where concrete is placed directly against earth, without formwork.

Bars, generally, shall be of the required lengths and the lapping of main bars will not be permitted, except as indicated on the Drawings. Where bars are required or permitted to be lapped, the parts along the lap shall have a clear space between them equal to 1cm or the diameter of the bar, whichever is the greater. The minimum length of overlap will be 40 times the diameter of the bars for hooked bars and at least 60 times the bar diameter for bars without hooks. Laps of adjacent parallel reinforcement bars shall be staggered. Ends of ties shall be cut back 1.5 cm from face and covered with mortar. Fabric reinforcement shall be lapped at least 40 diameters or two squares, whichever is the greater.

All laps of bars are to be tied tightly with six laps of 1.5 mm annealed iron wire at intervals of ten diameters of the bars. All crossings of steel are to be secured with three laps of wire. Splicing of bars by butt welding will be permitted, provided that the resulting joint is not inferior in strength to the rest of the bars. Bars depending for their strength on cold drawing or twisting shall not be spliced by welding. Crossings of steel bars may be secured by tack welding instead of tie-wires, provided that burning or other damage to steel attack-welds is prevented. All welds shall be done in a thoroughly workmanlike manner by qualified welders either by the oxy-acetylene method to BS 693 or by the metal arc method to BS 5135. Splices of bars having a diameter of 26 mm and more shall be done by butt-welding only.

The Contractor shall not pour any concrete before the Engineer has inspected and approved the placement of reinforcement. Such approval shall, however, not affect the Contractor's responsibility for the correctness of the reinforcement in accordance with the Drawings, reinforcement schedules, Specifications and/or directions given by the Engineer.

All reinforcing steels shall be Type 2 High Yield Bars and comply with the requirement of BS 8110 and shall have a specified characteristic strength of 420 N/mm².

Dowel bars and stirrups shall be Mild Steel grade 25, $f_y = 250 \text{ N/mm}^2$.

Lap lengths shall be 50 diameters. Mechanical bending for more than 12 mm is required.

3.8.5 Minimum Cover of Reinforcement

The concrete cover for all steel bars including stirrups shall not be less than 50 mm for one layer of reinforcement, and 40 mm for 2-faces reinforcement, in structures where concrete surfaces are in contact with water or with soil.

The cover of reinforcement in external surfaces of structures, and all elements of structures shall not be less than 40 mm.

Formwork for all concrete surfaces in contact with water and/or soil and internal surface (walls and ceilings) shall be of form panels (marine plywood or metallic formwork) in order to obtain a regular and smooth finish.

3.8.6 Classes of Exposure and Crack Width

The faces of structures in contact with ground shall also be considered as subject to severe exposure.

Concrete surfaces in contact with water are designed for a maximum crack width of 0.2 mm.

3.8.7 Admixtures

Admixtures (retarders, mass waterproofing, silica fume, ...) are to be added to concrete in contact with liquid. Technical sheets and the mix design of concrete shall be submitted for approval.

3.9 FORMWORK

3.9.1 General

The Contractor shall design, supply and fix all necessary formwork, together with its attendant scaffolding, timbering, shoring, strutting, etc., required for the placing of the concrete (ACI 347R).

The Contractor will be permitted to use timber boarding as formwork or forms lined with plywood, hardboard of approved manufacture or steel sheets. Where timber boarding is used, the formwork surfaces coming in contact with wet concrete shall be made of properly seasoned timber. Full size plywood or hardboard sheets shall be used except where otherwise required or where smaller pieces will cover the entire area. Forms shall be so placed that markings shall be symmetrical.

All formwork shall be of sufficient strength to resist movement of men or equipment and the pressure of the wet concrete while it is being placed and vibrated, without distortion. Where plywood, hardboard or steel lining is used, particular care shall be taken to ensure that the forms are adequately braced and stiffened.

The formwork for successive vertical lifts must make such perfect contact with concrete in the preceding lift that there shall be no excrescences, bulges, tears or other outward signs of faulty junction. The formwork must be constructed so

that there shall be no leaked of mortar. Whenever it is unavoidable, the Contractor shall prevent leakage of any kind through open joints by means of suitable caulking.

The repeated use of forms of all descriptions will be at the discretion of the Engineer, who will require the forms to be reconditioned or surfaced from time to time. After repeated use, the old forms will be replaced with new ones at the direction of the Engineer.

All exposed concrete shall have the external angles chamfered 20 mm or as directed by means of molding strips fixed to the formwork. Interior angles on such surfaces and edges at formed joints will not require beveling unless requirement for beveling is indicated on the Drawings.

The height of all erected at any one time shall be subject to the approval of the Engineer.

The surface of the forms shall be free from encrustation of mortar, grout, or other foreign material. Before the form panels or boards are erected in place, the surfaces of the forms shall be oiled with an approved commercial form oil that will effectively prevent sticking and will not stain the concrete surfaces.

3.9.2 Types of Forms

The surfaces of formwork to give a desired finish of formed concrete will be classified as follows:

- Unwrought Formwork of unwrought timber will be permitted in formwork for concrete surfaces or portions thereof which will receive plaster or other facing, or which will be covered up below ground level.
- Wrought Formwork (for Smooth Internal and External Surfaces) made of new plywood or new steel sheets or timber boarding planed on both sides to equal thickness, shall be used on all exposed concrete surfaces except where plaster or another facing or fair face concrete are provided for. The formwork shall ensure that a regular and smooth finish is obtained, free of excessive bulges, irregularities or unsightly markings or defects of any kind.
- Fair-face Concrete Formwork shall be employed where shown on the Drawings, required in the Specification or directed by the Engineer. This type of formwork shall include use of new plywood or new steel sheets equal thickness, joined by torque and groove joints in parallel and vertical or horizontal alignment, arranged so as to achieve concrete surfaces of the textures and patterns required.

Where the surfaces formed in wrought or fair-face formwork are defective, the Engineer may order repairs and, if large surfaces should be found honeycombed or otherwise impaired, he may order all such surfaces to be plastered with cement plaster. Repairs to fair-face concrete, where required, shall be made, but if in the Engineer's opinion such repairs would be insufficient to restore the external appearance of the surface, he shall order surfaces destroyed and cast anew.

The cost of all above-mentioned repairs to concrete surfaces, including application of cement plaster, and re-casting shall be deemed to be included in the unit rates for concrete work in the Bill of Quantities and shall not be paid for separately.

3.9.3 Form Ties

Embedded metal rods or sleeves used for holding forms shall remain embedded and shall terminate not less than 2½ cm from the face of the concrete. Embedded wire ties for holding forms will not be permitted in concrete walls which are to come into contact with liquids or where the concrete surfaces through which the ties would extend will be permanently exposed. Wire ties may be used for concrete walls to be plastered, stone faced or covered with earth. Wire ties shall be cut back at least 1.5 cm from the face of the concrete. The holes left in the concrete surfaces after cutting back of wire ties and removal of fasteners or holding rods or sleeves, and the insides of sleeves where sleeves are used, shall be completely filled with an approved non-shrinking mortar, and the mortar shall be finished flush with the concrete surfaces. This operation will be carefully carried out. The hole formed by the cutting process will be thoroughly cleaned and wetted before filling. The mortar will be of damp, not wet, consistency. The patch will be properly troweled smooth to match the surrounding concrete surfaces and shall be thoroughly cured by keeping it moist continuously for at least three days. After the patch has hardened, the Engineer may require the patch and the adjacent concrete surface to be ground down smooth. Any patches that are loose or hollow on completion must be re-done. Water stop tie rods shall be used for liquid retaining structures.

All costs for complying with the requirements of this Subsection shall be deemed to be included in the unit rates for formwork and shall not be paid for separately.

3.9.4 Striking of Forms

To facilitate satisfactory progress with the specified curing and to permit earliest practicable repair of surface imperfections, forms shall be struck as soon as the concrete has hardened sufficiently to prevent damage by careful form removal. Forms shall not be struck until the strength of the concrete is such that form removal will not result in perceptible cracking, breaking of surfaces, or other damage to the concrete and that the concrete can sustain the loads to be borne at the time of striking. Forms shall be struck with care so as to avoid injury to the concrete, and any concrete so damaged shall be repaired at the Contractor's expense.

No forms shall be removed without the express permission of the Engineer's Representative, but the Contractor shall, nevertheless, accept sole responsibility for the removal and consequences thereof.

In no case shall forms to soffits be struck until test cubes from the actual concrete concerned have yielded the 7 days' strengths specified.

If the striking times stated above are not sufficient to permit the unsupported concrete to sustain superimposed loads (such as support for the shuttering of an upper floor, storing of building materials, etc.). Such loads will require special supports to sustain them.

3.10 MISCELLANEOUS CONCRETE WORKS

3.10.1 MANHOLES AND CHAMBERS

Manholes and chambers shall be constructed in the positions and to the details shown on the Drawings. The grades of concrete and types of formworks shall be as shown on the Drawings, as required in the Specification or as directed by the Engineer. The inside dimensions, unless otherwise specified, or to otherwise finished surfaces.

A base slab of concrete, supporting the walls, shall be cast on firm ground foundations (so as to prevent any differential settlement), on a blinding layer of Lean Concrete (Grade C20). Where shown on the Drawings, smoothly constructed U-shaped channels, to carry and direct the flow, shall be formed integrally with the concrete base, or may be constructed separately by benching. Adjacent floor areas shall slope to drain to the channel with a gradient of about 5% to 10%..

All transition curves shall be smooth. The whole of the floor areas and channel surfaces shall be finished with a smooth coat of cement mortar.

The walls of the manholes shall be made of cast-in-situ concrete or of precast concrete rings, all as shown on the Drawings. The construction of walls shall not start sooner than 24 hours after slab had been cast. Cast-in-situ concrete and precast concrete shall be Grade C30 for floors, walls; ceilings and Grade C25 for benching. Precast concrete Chamber and Shaft rings shall conform to requirements of B.S. 556, shall be of the tongue and groove type and shall be assembled with cement-mortar joints to ensure complete water tightness of the joints.

Internal surfaces of Manholes and Chambers shall be absolutely smooth. This shall be achieved by the use of wrought formwork or fair faced concrete as shown on the Drawings or as directed by the Engineer.

Iron steps, or a ladder if so, shown on the Drawings, shall be provided in all manholes 1.25 m deep and over. The steps shall be staggered and spaced at about 30 cm vertically, or as shown on the Drawings. They shall be solidly embedded in the walls. The top step shall always be located to accommodate the right foot. Step irons for manholes shall comply with B.S. 1247 type A and shall be hot-dip galvanized. All steps shall be built in as the work proceeds. Cutting out completed work for inserting steps or other fittings shall only be permitted where it is impossible to build them in as the concrete is being cast. Unless otherwise specified, in manholes with depths greater than 5.25 m, ladders shall be

installed instead of steps. The ladders shall comply with the Drawings or shall be as specified or directed by the Engineer.

Where shown on the Drawings or directed by the Engineer, pipe stubs for future connections shall be installed. The stubs shall extend at least 50 cm beyond the outside of the walls of the manhole and shall be plugged water tightly. Appropriate channels for the future connections shall also be prepared in the benching.

Unless otherwise indicated, manhole and chamber covers shall be suitable and properly placed and installed, and shall be made of Galvanized steel or concrete with cast-iron frames, of a type approved by the Engineer. Suitable lifting keys of mild steel shall be provided with the covers at a rate of 1 set of keys for each 10 covers. After the completion of the work, cast iron parts of the covers and the frames shall be thoroughly cleaned and painted with bitumen paint.

Manholes shall be watertight. The Contractor shall, if so required, test them in the presence of the Engineer. The Contractor shall provide all water labour, drains, stoppers, bends and other needful appliances for carrying out tests and no manholes or other work must be covered up until they have been seen and passed by the Engineer. The test to be applied to manholes and chambers shall be their filling with water to 10 cm below the slab or to finished ground level and after allowing due time for saturation of the concrete, by topping up to the original level. Thereafter the loss of water shall not be greater than the equivalent of 2 cm over the whole area of the chamber in 24 hours.

3.10.2 Precast Concrete

All precast concrete members to be used in the works, such as pipes, covers, lintels, sills, slabs, stairs, etc., shall be manufactured on site or obtained from approved manufacturer. In either case casting shall be done under the supervision of the Engineer, whose approval of the place and method of casting must be obtained before starting work. If casting is done on the site, the Contractor shall prepare a suitable area near the structure for which the precast parts are intended, and samples of the precast work shall be submitted to the Engineer for approval before proceeding with the manufacture on site. Casting of the precast parts shall be completed in due time so as not to delay the completion of the structures and everything connected therewith.

Unless otherwise directed, precast elements shall be of concrete Grade C30P. All precast elements shall be true to dimensions and shapes as shown on the Drawings. Concrete surfaces shall be smooth and all corners square or chamfered, as shown on the Drawings or directed by the Engineer. Lifting lugs and similar metal parts, whether part of the reinforcement steel or not, shall be incorporated in the elements during manufacture. Precast elements shall not be transported or otherwise handled until the end of the curing period, which shall be at least 14 days.

Any precast concrete element becoming defective during casting or placing or from any other cause, and rejected by the Engineer, shall be removed from the Site by the Contractor who shall cast new elements to replace the rejected ones, and all expenses in connection therewith shall be borne by the Contractor.

4. METALWORK

4.1 GENERAL

4.1.1 Scope

The work required under this Chapter includes gratings, steel grids, sluice gates and miscellaneous non-structural metalwork and shall be in accordance with British Standards "BS".

The Contractor shall supply standard factory-made metal elements, ironmongery, paints and auxiliary materials required. The metalwork shall be manufactured at a steel fabrication shop and the Contractor shall install them in the required positions and paint them - all in accordance with the Drawings and the Specification, or as directed by the Engineer.

Steel for metalwork shall be new, first-grade quality mild steel, without mill defects, cracks, grooves or rough surfaces and shall comply with all requirements specified on the Drawings and/or in the Specification.

4.1.2 Metalwork

All shapes, bars and plates shall be cut, drilled, bent and otherwise worked to the exact lines and dimensions shown on the Drawings. All burrs resulting from cutting and drilling shall be neatly removed. Where cutting is done by oxyacetylene torch, cut surfaces shall be clean and smooth.

The Contractor shall take on site all dimensions deemed necessary for metalwork and remain wholly responsible for their good adaptation to the concrete and masonry works in the building.

Jointing shall be notched and angles mitered. Electric welding shall be as continuous as possible along the joint after filing the metal elements.

The Contractor shall supply and install any material whether specified or not on the Drawings, but necessary for the good execution of the works.

Surface finishing

Surface finishing of works shall include the protection of materials and the surface treatment.

Exposed surfaces shall have no unevenness, burrs, or metal run-out. Salient angles and projecting parts shall be rounded off. Welds shall be carefully ground. Screws shall be inserted and then painted. Accessible bolts shall be covered. Element showing appearance or assembly defects shall be rejected. It is expressly forbidden to cover and hide these defects.

Protection of metals against corrosion

No metal part shall be accepted on site unless previously protected against corrosion. Elements shall be in-factory protected according to relevant applicable standards. Unprotected iron parts shall be painted after removal of calamine, rust, and oil, with a rust proof zinc chromate paint, 60 microns thick, compatible with the top coat specified in the relevant Section (or eventually with two coats of red lead). Immediately after installation, any painted surface showing imperfections due to impacts or handling shall be wire brushed and repainted.

Contact between different metals

All measures shall be taken to avoid electrolytic corrosion caused by the contact between metal parts and accessories (screws, bolts, washers, etc.) of various natures.

4.2 WORKMANSHIP

4.2.1 Manufacture

Details and profiles shown on the Drawings constitute the basic Drawings. Works shall be solid, rigid and have a perfect finish. The components shall be one-piece. Connections shall be right- angled in such a manner as to resist, without deformation nor rupture, mechanical tests and the efforts imparted to them.

4.2.2 Assembly

Metalwork shall be fixed to their support (concrete and masonry works, partitions) by welded inserted plates, holdfasts, screws and expansion bolts or any other approved system. The use of a stud gun SPIT is prohibited. Anchor bolts shall only be used in concrete works or hollow blocks masonry; only traditional anchoring means are permitted for other surfaces. Anchors shall be screwed, bolted or welded on locks. Their section, shape, length and number are conditional upon the element sizes and installation conditions.

Fixing devices proposed by the Contractor shall be shown on shop Drawings. Fixing devices shall be placed close to hinges in order to diminish stresses.

All welding shall be done by the shielded electric-arc method by experienced welders, to the highest standards of workmanship and to the satisfaction of the Engineer. Electrodes for steel welding shall be of a kind and class approved by the Engineer. All surfaces of parts to be welded shall be well cleaned of dirt, rust, slag, and paint. All slag and splatter adhering to metal shall also be removed.

4.2.3 Installation

Prior to installation, the Contractor shall wedge and adjust the different elements so as to ensure perfect plumb, alignment and levelling.

He shall ensure all required sealing and caulking for fixing the works. He shall set out all his works and verify the location of openings left in the structure.

4.2.4 Tolerances

a) Tolerance on setting out

Maximal variation between the real position of each axis of metalwork and each axis of an opening in a wall shall not exceed 1 cm.

b) Tolerance on installation

Rectitude and plumb errors in door frames, stiles, and posts shall not entail a deviation exceeding 2 mm, provided that stiles and posts be parallel to 2 mm in all points and planes. Rectitude and levelling errors in crosspieces shall not exceed 2 mm for the first meter and 1 mm for each additional meter with a maximum of 4 mm.

c) Tolerances on leaves play

The play between leaves and the finished ground shall vary between 5 and 10 mm regardless of the opening position.

d) Sealing

Air and water tightness between the structure and the metalwork shall be ensured by stable and 10-year guaranteed sealants. They shall be easily replaced. The unit rates of metalwork shall include the cost of all sealants.

4.2.5 Handling and storage

Unloading and handling of elements shall be done without causing any permanent deformation or defect that might impair the good functioning of mobile parts, or their resistance to corrosion.

Elements shall be stored in dry premises on appropriate horizontal and vertical devices avoiding any deformation whatsoever.

4.2.6 Samples and mock-ups

Samples of hardware to be used shall be as shown on Drawings.

Prior to any serial manufacture, a mock-up of each type of work shall be submitted for approval, namely:

- Grids
- Protection bars
- Etc.

The Contractor shall submit to the satisfaction of the Employer all varnish samples.

4.3 RIPRAP WALL

4.3.1 Riprap Stone (Armor Layer)

- Material: Hard, durable, angular stone (quarried ledge rock or field stone), free from overburden, shale, or organic material. Class based on median diameter typically specifies size.
- Size: The description specifies 230–380 mm, which corresponds to a median particle size (D50) of approximately 230 to 380 mm. This aligns with a Class A or Class B riprap in some standards.
- Gradation: The stone must be well graded, meaning it should contain a mix of sizes from the smallest to the maximum specified to ensure stability and interlocking.
- Source: The work includes importing stones that are similar to those existing on site.

4.3.2 Concrete Grout (Bonding Agent)

- Strength: The grout must achieve a compressive strength of 20 MPa at 28 days. This aligns with the description for a standard grade of concrete.
- Application: The grout securely bonds the angular stones, creating a rigid, erosion-resistant armor. It is placed as a fluid grout, and compaction (e.g., by rodding) is required to ensure voids are not left, giving maximum stability.

4.3.3 Construction & Structural Details

- Formwork: Necessary formwork is required to contain the fluid grout during placement.

- Expansion Joints: These are critical to accommodate thermal movement and prevent uncontrolled cracking.
- Wall Thickness (TH): Specified as 500–800 mm.
- Filter Layer / Geotextile: A proper filter layer or geotextile fabric is implied to be installed beneath the system. This prevents the underlying soil from being washed out (piping) while allowing water to drain. The design of this layer typically follows specific retention and permeability criteria.

4.3.4 Aesthetics & Workmanship

- Appearance: The wall should have an aesthetic nature, blending in with the existing wall. This can involve using stone that matches the color and texture of the surroundings. The natural stone cladding not only integrates the wall into the landscape but also protects the structure.
- Quality: All materials and workmanship must be completed strictly as detailed in the specifications and to the full satisfaction of the Engineer

4.4 SLUICE GATE

4.4.1 Part Feature

- Frames and Gates

The materials utilized are high-duty cast iron, designed with robust ribbing to enhance resistance against deflection.

The frame connections are either flat back or spigot type, allowing for integration into concrete, with the spigot end type offering additional rigidity to the frame.

For both circular and rectangular penstocks, flange connections are available upon request. These connection types facilitate the bolting of the installation to the flange inlet pipe and the wall thimble. Each side of the frame is equipped with guide channels for the gate, extending to a sufficient height to ensure that the gate is supported over at least two-thirds of its depth when fully lifted

- Body and Gate Seat

Typically, these comprise bronze seating strips made of robust rectangular sections that are affixed to machined surfaces on both the body and the gate, which are subsequently ground together to create a watertight bearing. Additionally, bronze strips are installed as bearing surfaces in the guides where the gate ascends.

- Wedges

Each side of the frame features vertically extending cast iron cover bars equipped with adjustable blocks to restrict the downward movement of the gate.

In situations where a tight seal is necessary and pressure may push the gate away from the frame, additional wedges are installed at the top and bottom. For instances requiring robust support due to significant loading, the top wedging consists of a cast iron wedge bar that spans the gate, with tapered faces that interact with the gate wedges.

The quantity of wedges supplied is contingent upon the dimensions and configuration of the penstock, as well as the prevailing pressure conditions.

- Stems

Both rising and non-rising stem constructions are offered. In the non-rising configuration, the operating threads connect with a tapped lifting nut situated between lugs at the gate's head, while the gate itself is designed with a barrel to accommodate the stem's projection when in the open position.

Conversely, in the rising type, the stem is affixed to the stem nut and features the operating thread at the upper end, which engages a revolving nut within the actuator.

All stems are appropriately sized for their intended use and are equipped with machine-cut threads of stub acme form.

High-quality materials that meet service requirements are utilized, with the selection based on factors such as the fluid type, operating load, and the distance from the gate to the actuator. Aluminum bronze and stainless steel are commonly used alternatives.

4.4.2 Material of Construction

PARTS	TYPES		
	CI SERIES	SG SERIES	SS SERIES
FRAME	CAST IRON ASTM A 126 CLASS B <i>BS EN 1561-EN-GJL-250</i>	SG IRON (DUCTILE IRON) ASTM A 536 GRADE 65-45-12 <i>BS EN 1563-EN-GJS-500-7</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>
GATE	CAST IRON ASTM A 126 CLASS B <i>BS EN 1561-EN-GJL-250</i>	SG IRON (DUCTILE IRON) ASTM A 536 GRADE 65-45-12 <i>BS EN 1563-EN-GJS-500-7</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>
STEM	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>
STEM NUT	GUNMETAL ASTM B 62 <i>BS EN 1982-CC491K</i>	GUNMETAL ASTM B 62 <i>BS EN 1982-CC491K</i>	GUNMETAL ASTM B 62 <i>BS EN 1982-CC491K</i>
BODY SEAT GATE SEAT	GUNMETAL ASTM B 62 <i>BS EN 1982-CC491K</i>	GUNMETAL ASTM B 62 <i>BS EN 1982-CC491K</i>	GUNMETAL ASTM B 62 <i>BS EN 1982-CC491K</i>
	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>
TOP WEDGE	STEEL ASTM A 36 <i>BS 1506</i>	STEEL ASTM A 36 <i>BS 1506</i>	STEEL ASTM A 36 <i>BS 1506</i>
BOTTOM WEDGE SIDE WEDGE WALL THIMBLE	CAST IRON ASTM A 126 CLASS B <i>BS EN 1561-EN-GJL-250</i>	SG IRON (DUCTILE IRON) ASTM A 536 GRADE 65-45-12 <i>BS EN 1563-EN-GJS-500-7</i>	STAINLESS STEEL ASTM A 276 TYPE 304 <i>BS 970 GRADE 304</i>
	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>	STAINLESS STEEL ASTM A 276 TYPE 304,316 <i>BS 970 GRADE 304,316</i>

4.4.3 Design Features

- Simple installation
- Reduced operation torque
- Cast Iron, Ductile Iron, Fabricated Stainless Steel and Fabricated Steel
- Meet the requirement of AWWA C-501: 1992, BS 7775: 1995

4.4.4 Gate Openings

Three types of opening are available:

- Square
- Rectangular (Width x Height)
- Round

5. WATERPROOFING

5.1 GENERAL

The provisions of this division shall apply only to the:

- Damp-proofing of back filled new concrete retaining walls against infiltrated water.
- Damp-proofing below slab and over walls of concrete structures retaining aqueous liquids against infiltrated water.
- Damp-proofing of cut-off walls and tunnels in catchment structures.

5.2 MATERIALS

Damp-proofing materials are intended to provide a resistance against water and sometimes against humidity and water vapor.

5.3 BITUMINOUS COATING

This material is recommended for use on the exterior wall basement of plant rooms (excluding electrical equipment) in some workshops and retaining walls where water infiltration pressure is low (permeable earth foundation) and where the preformation level of protection tolerates some damp patches.

Ground water should be checked previously by the Contractor for chemicals which may have a deleterious effect on the structure or internal finishes.

The Contractor must obtain the previous approval of the Engineer on the support as well on the type of material proposed.

(Type B for reinforced concrete design in accordance with B.S. 8110).

The bituminous coating for damp-proofing should be cold applied emulsion in two coats (of at least 0.750 kg/ m² each) and cross applied.

Bitumen primer should be of the same cold bitumen emulsion compound diluted to 50% with water and applied at a minimum rate of 0,400 kg/ m². The damp-proof bituminous coat shall be applied around 24 hours after the primer application.

6. PIPELINES AND PIPEWORKS

6.1 SCOPE

This part of the specification shall apply to the supply, delivery, laying, jointing and testing of all pipes, fittings and accessories, and includes:

- Concrete pipes
- P.V.C. pipes

6.2 CONCRETE PIPES

6.2.1 Quality Requirements

Concrete pipes, fittings and junctions shall comply in all respects with B.S. 5911 or ASTM C76M for reinforced concrete pipes or with B.S.5911 or ASTM C14M or DIN4032 for non-reinforced concrete pipes. The pipes shall be truly circular and have bell joints, or spigot and socket joints, or rubber gasket joints, as noted on the Drawings or in the Bill of Quantities, and as specified hereafter.

Concrete pipes, fittings and junctions shall be tested for compliance with B.S. 5911 (and BS EN681- 1:96 or DIN 4060/2 for jointing system) in approved laboratories or in their place of manufacture. The pipes shall be subjected to Hydraulic and Crushing Tests. The number and selection of samples for testing, the test procedures and the requirements shall all be as specified in B.S. 5911.

The selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the test site and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

Alternatively, the contractor may submit to the engineer certificates from approved laboratories certifying that the pipes have been subjected to and have satisfactorily undergone the required tests according to the specified standards. In that case the Engineer shall be entitled (but shall not be bound) to renounce any further testing.

6.2.2 Hauling and Handling of Pipes

The entire curing period of the pipes shall be completed before any pipe shall be loaded and transported. The Contractor shall check each pipe before loading and shall reject all damaged or defective pipes. The Contractor shall load with the

greatest care and properly secure the pipes on the vehicles for transportation and take all necessary measures to prevent any damage to the pipes during transport. The Contractor shall be responsible for the quality of the pipes and for their condition upon and after delivery to the Site. The Engineer will check the pipes upon their delivery to the Site and the Contractor shall forthwith remove from the Site all rejected pipes and replace them at his own expenses by pipes acceptable to the Engineer. Only pipes inspected and accepted on the Site by the Engineer shall be incorporated in the Works.

The Contractor shall ensure that all pipes are properly handled by his staff. During transport, pipes shall not be allowed to rest on their joints, narrow cross-members of vehicles, or anything else that might give rise to concentrated loads due to the weight of the pipe or bumping of the vehicle but shall be properly supported on soft material. Sufficient labour and equipment shall be on hand before loading and unloading is commenced and under no circumstances shall any pipe be dropped from a vehicle. For storage on site, the ground must be level and free from loose stones.

The Engineer shall have the right to reject consignments or stocks of pipes from which failed pipes have been drawn, or order them to be pressure-tested outside the pipelines, even though no defects are apparent, if there is reason to believe that mishandling has taken place. All costs incurred in this respect shall be borne by the Contractor.

6.2.3 Laying of Pipes

After the excavation and preparation of a section of pipe trench has been completed by the contractor, it shall be inspected by the Engineer. No pipe shall be laid before the excavation has been approved by the Engineer. Just before pipe laying, the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipe laying shall be carried out by experienced pipe-layers well skilled in this work. Pipes shall be laid true to line by means of a line stretched along the side of the pipes and true to level by means of a straight edge of 4 meters in length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

Immediately before being laid, each pipe and fitting shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if, in his opinion, dirt is not being satisfactorily excluded. The badger on a sound rope is to remain within the bore of the pipe previously laid and jointed and is to be drawn forward as the work proceeds throughout the whole length of the conduit. The badger is to be of soft material which will not damage the internal surfaces of the pipes.

In order to prevent stones, soil or small animals from entering the pipe, a suitable cap end or plug shall be provided with which the last pipe laid shall be sealed when pipe laying is not actually in progress. The plug shall be of the screw-up expanding type or of tapered wood.

6.2.4 Jointing

Rubber Gasket Joints - Where pipes with bell and spigot joints and rubber sealing gaskets are approved by the Engineer, the following provisions shall apply to jointing: rubber gaskets shall be of synthetic rubber resistant to oils and fats, and shall meet the requirements of (B.S. EN681-1 or DIN 4060/2) - Elastomeric Joint Rings for Pipework and Pipelines (Types 1 and 2) or of I.S.O.1398.

All pipes, and especially the bells and spigots, as well as the rubber gaskets shall be carefully inspected before being incorporated into the work, and no defective pipes or gaskets shall be used. Before making any joints, the rubber gaskets, spigot and bell shall be well cleaned and thoroughly covered with a special lubricating compound not harmful to rubber, as approved by the Engineer. After lubrication, the rubber gasket shall be stretched around the spigot of the pipe to be laid and fitted into the groove, care being taken to ensure uniform tension and to prevent twisting of the gasket. The spigot with the gasket on it shall then be inserted into the bell of the previously laid pipe and the new pipe shoved into position. Shoving-in may be done while the pipe is still suspended from the crane or lifting tackle to minimize friction between pipe barrel and trench bottom.

The bell, spigot, and gasket shall be protected from contact with earth, dirt, or any other deleterious matter until the joint is completed. The use of undue force to overcome improper fitting of the gasket into the spigot groove shall not be permitted, since this may cause twisting or dislocation of the gasket resulting in a faulty joint. If the pipes are properly aligned, the gasket properly fitted and the gasket and bell well lubricated, the pipe should slide in smoothly without the application of much force.

6.2.5 Final Cleaning and Inspection

Before the works are accepted by the Engineer, the entire pipe system, including all structures, shall be thoroughly cleaned by flushing or by passing a brush, sphere or other suitable tool through it, or by any other approved method, to ensure that it is clean, and free of obstructions and that pipe runs are perfectly straight. Before taking over, the pipeline will be finally inspected by the Engineer.

6.2.6 Methods of Measurement and Payment

Precast concrete pipes and cast-in-situ R.C. conduits shall be classified for payment according to type and diameter and shall be measured for payment in linear meters or as indicated in the B.O.Q. of completed pipeline in place, measured along the crown of the pipeline, between internal surfaces of manholes or chambers and the length measured for payment shall include the lengths of all fittings, specials, junctions, bends, etc. installed in the pipeline.

The price of fittings, specials, bends, junctions, etc. for precast concrete pipes and cast-in-situ R.C. conduits shall be, unless otherwise specified in the specifications or the B.O.Q. considered as included in the cost of pipes.

Payment for precast concrete pipes and for fittings, specials, etc., shall include:

- Supply, hauling, handling, unloading and stacking of pipes and fittings including all necessary jointing materials.
- Removal from stacks; hauling and stringing alongside trench; laying, jointing and testing at any depth of trench; and final cleaning and flushing of pipeline. The unit rates for this item, for each type and diameter of pipe and fitting, shall be the same for all depths of trench in which the pipes and fittings are to be installed.

Only pipes, fittings, junctions, bends, etc. actually laid in trench, and tested and accepted by the Engineer, shall be measured for payment above, and no allowance whatsoever will be made for any breakage, loss, etc. in route.

6.3 P.V.C. PIPES

6.3.1 Quality Requirements

P.V.C. pipes and fittings shall comply in all respects with the following standards:

- B.S. 3506 Unplasticized P.V.C. pipes for industrial uses.
- EN1452 Outside Diameters and Pressure Ratings of Pipe of Plastics Materials.
- EN1329 Unplasticized P.V.C. Underground Drain Pipe and Fittings.

All pipes and fittings shall be supplied by approved manufacturers. Class of pipes shall be as stated in the Drawings or in the Particular Specification. The nominal length of pipes shall be not less than 6.0 m and not greater than 9.0 m.

P.V.C. pipes shall be factory tested and shall be subjected to Hydraulic and to Impact (Falling Weight) Tests. The number and selection of samples for testing, the test procedure and the requirements shall all be as specified in the relevant EN. If so, directed by the Engineer, the selection of samples and the Tests shall be witnessed by a representative of the Engineer, who shall be informed at least 48 hours in advance of any sampling or testing.

The cost of samples, their transportation to the laboratory and their testing shall be deemed to be included in the unit rates and shall not be paid for separately.

6.3.2 Hauling, Handling and Storage

Rough handling of pipes shall at all times be avoided, especially at low temperatures. During storage and transport, rigid P.V.C. pipes shall have as near continuous support as possible at all times, and care shall be taken to avoid damage to pipe by sharp edged angle irons, exposed nail heads, etc.

For long term storage in average ambient temperature, attention shall be paid to stack heights to avoid the possible deformation of the pipe diameters. A maximum stack height of 1 meter is recommended. For temporary storage on site, care shall be taken to ensure that the ground is level and free from bricks, stones and sharp edges. At high temperatures, rigid P.V.C. pipes shall be kept in the shade during long term storage. P.V.C. pipes with spigot and socket shall be stacked with the sockets protruding in alternate layers. Pipes bent, deformed in any way or changed in color shall be rejected and no payment whatsoever shall be made for such pipes.

While transporting, the pipes shall not overhang the vehicle by more than 0.6 m. Pipe loads shall not be stacked higher than 2.0 m.

Where pipes are transported one inside another, care shall be taken that:

- The pipes are clean and free from grit.
- Suitable covering be provided over the exposed ends of the pipes to prevent the entry of grit during transport.
- The pipes in the lower layers are not excessively loaded to such a degree as would cause damage or undue distortion.

6.3.3 Laying and Jointing

After the excavation and preparation of a section of pipe trench has been completed, it shall be inspected by the Engineer. Just before pipelaying the trench shall be cleaned of all stones, soil and other debris that might have fallen therein.

All pipelaying shall be carried out by experienced pipe-layers, well skilled in this work.

Immediately before being laid, each pipe and fittings shall be carefully examined both inside and outside for any damage, and all dust, dirt and foreign matter shall be removed. Care shall be taken to ensure that they remain clean during laying. The use of a badger will be ordered by the Engineer, if in his opinion, dirt is not being satisfactorily excluded. The badger, on a sound rope, is to remain within the bore of the pipe previously laid and jointed and it is to be drawn forward as the work proceeds throughout the whole length of the sewer. The badger is to be of soft material which will not damage the internal surface of the pipes.

In order to prevent stones and soil from entering the pipe, a suitable cap or plug shall be provided with which the last pipe laid shall be closed when pipelaying is not actually in progress. The plug will be of the screw-up expanding type or of tapered wood.

Where bends are required, performed bends of the desired radii shall be used. Hot bending on site is not permitted.

All joints shall be flexible, with approved rubber rings. Rubber rings shall comply with B.S. EN681-1 (Elastomeric Joint Rings for Pipework and Pipelines) and shall be of the type designated on the Drawings, or in the Particular Specification, or as directed by the Engineer.

Pipe lengths and fittings shall be supplied with a chamfer on the spigot end. Where pipes have to be cut to length, the pipe shall be cut square and a chamfer formed on the spigot end using a medium file. Any saw flushing shall be scraped off with a knife. The spigot and

socket shall be free from mud or grit, and the ring correctly located in its groove. A lubricant approved by the Engineer shall be applied to the chamfered portion of the spigot before its insertion in the socket.

Flanges complying with B.S. 4504 (flanges and Bolting for Pipes, Valves and Fittings, metric units) shall be used for the jointing of P.V.C. pipes with steel pipes and for the connection of valves and other appurtenances. The joint shall be made by compression of a gasket or ring seal set in the face of the flange.

Pipes shall be laid true to line by means of a line stretched along the sides of the pipes and true to level by means of a straight edge of suitable length kept inside the pipes and pulled forward to pegs boned in at suitable intervals between sight rails set to the proper levels.

6.3.4 Testing

Testing instructions and requirements for P.V.C. gravity pipelines shall be as specified as mentioned for concrete pipelines except that the leakage under test shall not exceed 0.08 liter/ m² of internal wall pipe area/hour. Testing instructions and requirements for P.V.C. pressure pipelines shall be as specified for A.C. pressure pipes, except that the Hydrostatic pressure test can commence 24 hours after the completion of filing if permitted by the Engineer.

6.3.5 Methods of Measurements and Payment

P.V.C. pipes shall be classified for payment according to type, diameter and class and shall be measured in linear meters or as mentioned in the BOQ of completed pipeline in place, along the crown of the pipeline, as follows:

In gravity flow lines: between internal surfaces of manholes or chambers.

The length measured for payment shall include the length of all fittings, valves and specials installed in the line.

The price for fittings, specials, junctions, bends, detachable joints, valves, etc., shall be classified for payment according to type, diameter and class; shall be considered as included in the cost of pipes, unless otherwise specified in the particular specifications or the B.O.Q.

Alternatively, if so, stated in the Particular Specification and/or in the Bill of Quantities, pipe and fittings may be measured by number of pipes of defined net lengths and by number of fittings.

Payment for P.V.C. pipes and for fittings; specials etc. shall include:

- Supply, hauling, unloading and staking of pipes and fittings including all necessary P.V.C. joints and jointing materials for pipes and all P.V.C. joints and jointing materials for fittings, specials, valves, etc.
- Removal from stacks, hauling and stringing alongside the trench, laying and jointing of pipes and fittings at any depth of trench, connections to manholes

and/or chambers and final cleaning and flushing of pipeline. The unit rates for this item for each type, class and diameter of pipe and fitting shall be the same for all depths of trench in which the pipes and fittings are to be installed.

- Testing of completed pipeline

For gravity pipelines: the cost of testing shall be included in the unit rates for pipes and shall not be paid for separately.

Only pipes, fittings, junctions, bends etc. actually laid, in trench and tested and accepted by the Engineer shall be measured for payment under the above items, and no allowance whatsoever will be made for any breakage, loss, waste, etc.

7. ROAD SURFACING WORKS

7.1 GENERAL

Road surface works under this division shall include the rehabilitation of existing agricultural roads where such repairs are necessitated by the performance of the Works, and the term “road” as used in this division shall also include other areas on which a road surfacing is required.

All roads shall be constructed to the lines, levels and cross-sections shown on the Drawings and as detailed in the specification. Road surfacing may consist of compacted local soil, gravel, laterite or similar suitable material.

7.2 ROAD SUB BASE

7.2.1 Description

This item shall consist of a sub base course composed of granular materials, constructed on a prepared subgrade or underlying course in accordance with this specification and in conformity with the dimensions shown on the drawings and with the lines and grades as established by the EIIP Engineer. The activity is the supply of suitable sub base materials on site, spreading on a compacted sub grade layer and compaction.

Materials selected for use as road sub base should be with proper proportion of gradation and fine material that meet the requirements in the specification and shall be free of lumps of organic, or other deleterious materials.

7.2.2 Materials

The sub base material should have the following characteristics:

The Subbase material shall consist of hard durable particles or fragments of granular aggregates. The material will be mixed or blended with fine sand, stone dust, or other similar binding or filler material produced from approved sources. This mixture must be uniform and shall comply with the requirements of this specification and shall be capable of being compacted into a dense and stable sub base. The material shall be free from vegetable or organic, matter, lumps, dirt or clay, and other objectionable or foreign substances.

The combined dry aggregate delivered to the site shall have the gradation of class A or class B material as shown in the following table, when tested in accordance with AASHTO T-27 after dry mixing and just before spreading and compacting.

The class of granular material to be used shall be as shown on drawings or as selected by the Engineer. The actual gradation shall, in all cases, be continuous and smooth within the specified limits for each class.

ASTM sieve	Percentage of dry weight passing	
	Class A	Class B
2"	100	100
1"	-	75-95
3/8"	30-65	40-75
No. 4	25-55	30-60
No. 10	15-40	20-45
No. 40	8-20	15-30
No. 200	2-8	5-20

The sub base material shall pass the following tests and the results shall be within the following limits:

Liquid Limit (AASHTO T89)	25
Max. Plasticity Index (AASHTO T90)	6
Max. Sand Equivalent (AASHTO T176)	25
Min. Loss by Abrasion (AASHTO T96)	35 Max

The selection of the grading within this envelope shall however be such that the maximum size aggregate used shall be not more than one-half of the thickness of the layer to be constructed. Maximum size of aggregate should not exceed 100 mm).

The CBR of a laboratory compacted sample shall be not less than 60%. Samples shall be prepared in accordance with ASTM D 1883, and shall be soaked for four days.

a) Operation in pits and quarries

All work involved in clearing and stripping of quarries and pits including handling unsuitable material encountered shall be performed by the Contractor at his own expense. The material shall be obtained from sources that have been approved. The material in the pits shall be excavated and handled in such a manner that a uniform and satisfactory product can be secured. Unless otherwise directed, pits shall, if possible, be

adequately drained and shall be left in a neat and presentable condition with all slopes dressed uniformly. Quarries shall be left as neat and presentable as practicable.

b) Plant mixing

When materials from several sources are to be blended and mixed, these materials shall be processed in a central or travelling mixing plant. The material, together with any blended material, shall be thoroughly mixed with the required amount of water. After the mixing is complete, the material shall be transported to and spread on the underlying course without undue loss of the moisture content.

c) Materials acceptable in existing condition

When material is secured in a uniform and satisfactory condition, such approved material may be moved directly to the spreading equipment for placing. The materials from these sources shall meet the requirements for gradation, quality and consistency. The moisture content of the material shall be brought up to approximately that percentage required to obtain maximum density. Any deficiency or excess of moisture may be corrected by surface sprinkling or by aeration. In such instances, mixing or manipulation may be required, immediately preceding the rolling, to obtain the required moisture content.

7.2.3 Method

The following steps should be followed:

Before any sub base material is placed, the underlying course shall be prepared and conditioned as specified. The course shall be checked and accepted by the Engineer before placing and spreading operations are started.

The sub base shall be constructed in layers. Spread the delivered sub base material by labour in layers as specified in the drawing, no thicker than 20 cm and to a camber (surface slope/cross fall) of 4% in case of crowned and 3% in case of undivided planar.

The material, as spread, shall be of uniform gradation with no pockets of fine or coarse materials. No material shall be placed on a soft or muddy course. During the placing and spreading, sufficient caution shall be taken to avoid segregation. Exercised to prevent the incorporation of subgrade, or foreign material in the sub base mixture.

After spreading the material shall be thoroughly manually compacted by rolling and sprinkling, when necessary. Sufficient rollers shall be furnished to adequately handle the rate of placing and spreading of the course.

Compaction shall progress gradually from the sides to the center of the lane under construction, or from one side towards previously placed material, by lapping uniformly each preceding track by at least 200mm.

The compaction shall continue until the material is thoroughly set and stable, and the course has been compacted to not less than 100% of maximum dry density at optimum moisture as determined by ASTM D 1556, Method D.

Tests for field density shall be made in at least one location for every 500 square meters of each compacted layer in accordance with ASTM 1556. Blading and rolling shall be done alternatively, as required or directed, to obtain a smooth, even, and uniformly compacted course. The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes undulation in the underlying course or sub base. Water shall not be added in such a manner or quantity that free water will reach the underlying layer and cause it to become soft.

Along places inaccessible to rollers, the material shall be tamped thoroughly with mechanical tampers, until satisfaction compaction is obtained. Each layer of sub base course must be completely compacted and approved by the Engineer prior to the delivery of the materials for the succeeding layer.

7.2.4 Equipment

This activity requires hand tools and haulage equipment (trucks) to carry the base material and manually compaction equipment (mechanical stamper).

7.2.5 Safety on site

Workers must be well spaced to limit the risk of injury when using hand tools. All operators must be trained in the use of their equipment (water truck, tampers). Equipment must be in good condition and safety covers for moving parts should be used.

Safety gear includes closed shoes and gloves

7.2.6 Checking

A simple laboratory tests shall be carried out to test the gravel for grading, particle strength, particle shape and plasticity before using the quarry. The strength of the compacted layer should be checked by DCP.

a) Surface finish tests

After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and level, any portion found to lack the required smoothness or to fail in accuracy of grade or level shall be scarified, reshaped, re-compacted, and otherwise manipulated as the Engineer may direct until the required smoothness and accuracy are obtained. The finished surface shall not vary more than 10 mm when tested with a 3-meter straightedge applied parallel with and at right angles to the center line.

b) Thickness and finished levels

The thickness of the completed course may be checked by depth tests or cores taken at intervals, so that each test shall represent no more than 400 square meters.

Deficiencies in thickness are allowed between the tolerances for elevation of the underlying layer and the top of the constructed course.

The elevations of the finished surface shall not vary more than 10mm from the design elevations. The leveling of the finished course shall be performed by the Contractor in a grid as indicated by the Engineer. The Contractor shall submit all levels in due time to the Engineer for checking and approval. Any deviation of the finished elevations from the design elevations outside the tolerances, shall be corrected by the Contractor by scarifying, removing and/or adding material, sprinkling, rolling, reshaping, and finishing in accordance with these specifications. The Contractor shall replace at his expense the material when borings are taken for test purposes.

7.3 ROAD BASE COURSE

7.3.1 Description

This item shall consist of a gravel (tout-venant) composed of a mixture of crushed stone and stone dust materials, constructed on a compacted existing road surface or sub base layer in accordance with this specification and in conformity with the dimensions shown on the drawings and with the lines and grades as established by the EIIP Engineer. The activity is the supply of selected gravel (tout-venant) materials on site, spreading on a compacted existing surface or sub base layer and compaction. Materials selected for use as road gravel surface should be with proper proportion of gradation and fine material that meet the requirements in the specification and shall be free of lumps of organic, or other deleterious materials.

7.3.2 Materials

The aggregate shall be either crushed gravel or crushed stone. The fine aggregate shall be screenings obtained from crushed stone or crushed gravel.

The crushed gravel and stone shall consist of hard durable stones, rock, boulders, large cobble stones etc. crushed to specified sizes and shall not contain more than 8% flat, elongated, soft or disintegrated pieces, dirt or other objectionable matter.

A flat particle is one having a ratio of width to thickness greater than 3 and an elongated particle is one having a ratio of length to width greater than 3. The method used in production of crushed gravel and stone shall be such that the finished product shall be as uniform as practicable. The crushing shall result in a product, of which the material retained on a No. 4 sieve shall have at least 90% by weight of particles with at least one fracture face.

Each fractured face shall have an area being at least equal to 75% of the smallest mid-sectional area of the particle. When two fractures are adjacent, the angle between the planes of the fracture must be at least 300 to count as two fractured faces.

If so required gravel and rock etc. shall be screened before crushing to meet the requirements or to eliminate an excess of fine particles. All inferior materials and excess fine aggregates shall be wasted.

The crushed aggregate shall have a percentage of wear of not more than 30 after 500 revolutions as determined by ASTM C 131 (Los Angeles Rattler Test).

The gradation shall be within the limits of the gradations shown in the following table:

Gradation Requirements for Base Course or re-graveling

			Mass Percent Passing			
ASTM Sieve	Grading	Grading	Grading	Grading	Grading	Grading
	A	B	C	D	E	F
1 in.	---	75-95	100	100	100	100
3/8 in.	30-65	40-75	50-85	60-100	---	---
No. 4	25-55	30-60	35-65	50-85	55-100	70-100
No. 10	15-40	20-45	25-50	40-70	40-100	55-100
No. 40	8-20	15-30	15-30	25-45	20-50	30-70
No. 200	2-8	5-20	5-15	5-20	6-20	8-25

The gradations in the table represent the limits which shall determine the suitability of aggregate. The final gradation decided on within the limits designated in the table shall be uniformly 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.

The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one-half the fraction passing the No. 40 mesh sieve.

The portion of the aggregate, including any blended material, passing No. 40 mesh sieve shall have a liquid limit of not more than 25% and a plasticity index of not more than 6% when tested in accordance with ASTM D 423 and D 424.

The crushed aggregate base course material shall have 4 days soaked CBR of not less than 80, when compacted at 100% of modified proctor according to ASTM D-1557 (method D) and tested in accordance with ASTM D-1883.

a) Additional fine material

If additional fine material, in excess to that naturally present in the base course material is necessary for correcting the gradation to the limitations of the specified gradation, or for changing the soil constants of the material passing the No. 40 mesh sieve, it shall be uniformly blended and mixed with the base course material at the crushing plant or by an approved blending plant. There shall be no reworking of the base course material in place to obtain the specified gradation. The additional fine material for this purpose shall be obtained from the crushing of gravel and/or stone.

For cement stabilized base course road surface option, fresh Portland cement is used.

b) Plant mixing

The selected gravel shall be uniformly blended during crushing operations or mixed in an approved blending plant. The type of plant may be either a central proportioning and mixing plant or a travelling plant. The plant shall blend and mix the materials to meet these specifications and to secure the proper moisture content for compaction.

Whenever there is a change in the material source a full set of tests shall be required.

7.3.3 Method

The following steps should be followed:

Before any gravel material is placed, the existing road surface or sub base layer shall be prepared and conditioned as specified. The prepared existing road surface or sub base layer shall be checked and accepted by the Engineer before placing and spreading operations are started.

The gravel shall be constructed in layers. Spread the delivered gravel material by labour in layers as specified in the drawing, no thicker than 20 cm and to cross slope of 4% in case of crowned and 3% in case of undivided planar.

The material, as spread, shall be of uniform gradation with no pockets of fine or coarse materials. No material shall be placed on a soft or muddy course. During the placing and spreading, sufficient caution shall be taken to avoid segregation.

After spreading the material shall be thoroughly manually compacted and sprinkled, when necessary. Sufficient rollers shall be furnished to adequately handle the rate of placing and spreading of the base course.

Compaction shall progress gradually from the sides to the center of the lane under construction, or from one side towards previously placed material, by lapping uniformly each preceding track by at least 300mm.

The compaction shall continue until the material is thoroughly set and stable, and the course has been compacted to not less than 100% of maximum dry density at optimum moisture as determined by ASTM D 1557, Method D.

Tests for field density shall be made in at least one location for every 500 square meters of each compacted layer in accordance with ASTM 1556. The gravel shall not be rolled when the underlying course is soft or yielding or when the rolling causes undulation in the underlying course. Water shall not be added in such a manner or quantity that free water will reach the underlying layer and cause it to become soft.

Along places inaccessible to rollers, the material shall be tamped thoroughly with mechanical tampers, until satisfaction compaction is obtained. Each layer of base course must be completely compacted and approved by the Engineer.

For cement stabilized base course road surface option, mixing cement and aggregate shall be done on site by manual labour with appropriate hand tools.

7.3.4 Equipment

This activity requires hand tools and haulage equipment (trucks) to carry the base material and manually compaction equipment (mechanical stamper).

7.3.5 Safety on site

Workers must be well spaced to limit the risk of injury when using hand tools. All operators must be trained in the use of their equipment (water truck, tampers). Equipment must be in good condition and safety covers for moving parts should be used.

Safety gear includes closed shoes and gloves.

7.3.6 Checking

A simple laboratory tests shall be carried out to test the gravel for grading, particle strength, particle shape and plasticity before using the quarry. The strength of the compacted layer should be checked by DCP.

a) Surface finish tests

After the course is completely compacted, the surface shall be tested for smoothness and accuracy of grade and level, any portion found to lack the required smoothness or to fail in accuracy of grade or level shall be scarified, reshaped, re compacted, and otherwise manipulated as the Engineer may direct until the required smoothness and accuracy are obtained. The finished surface shall not vary more than 10 mm when tested with a 3-meter straight edge applied parallel with and at right angles to the center line.

b) Thickness and finished levels

The thickness of the completed road surface may be checked by depth tests or cores taken at intervals, so that each test shall represent no more than 400 square meters.

Deficiencies in thickness are allowed between the tolerances for elevation of the underlying layer and the top of the constructed base course.

The elevations of the finished surface shall not vary more than 10 mm from the design elevations. The leveling of the finished road surface shall be performed by the Contractor in a grid as indicated by the Engineer. The Contractor shall submit all levels in due time to the Engineer for checking and approval. Any deviation of the finished elevations from the design elevations outside the tolerances, shall be corrected by the Contractor by scarifying, removing and/or adding material, sprinkling, rolling, reshaping, and finishing in accordance with these specifications. The Contractor shall replace at his expense the material when borings are taken for test purposes.

7.4 ROAD WEARING COURSE (ASPHALT PAVING)

7.4.1 Description

1.1 SUBMITTALS

- A.** Product Data: For each product specified. Include technical data and tested physical and performance properties.
- B.** Detailed Design calculation based on heavy truck loading as per AASHTO criteria
- C.** Job-Mix Designs: For each job mix proposed for the Work.
- D.** Shop Drawings: good for construction, indicate pavement markings, lane separations, and defined parking spaces. Indicate dedicated handicapped spaces with international graphics symbol, where shown on Drawings.
- E.** Qualification Data: For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by Supervision Consultant.
- F.** Material Test Reports: From a qualified independent testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 - 1.** Classification according to AASHTO of each on-site and borrow soil material proposed for fill.
 - 2.** Relative compaction test results as well as all other laboratory test results submitted to the Supervision Consultant on a monthly basis.
 - 3.** Test results that represent average results for produced materials not over two (2) years old.
- G.** Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

- H.** Samples: 14-kg samples, sealed in airtight containers, of each proposed soil material from on-site or borrow sources.
- I.** Method statement: Prior to commencing any work, the Contractor shall submit a 'Method Statement' detailing how each item of work will be performed, including:
 - 1.** Leveling Plan.
 - 2.** Methods of compaction and carrying out site grading.
 - 3.** Control of water and dewatering plan.
 - 4.** List of tools, equipment and transport trucks to be used.
 - 5.** Supervision and control system.
 - 6.** Speed bumps and studs installation.
- J.** Quality control program.
- K.** Weekly and monthly quality control reports.
- L.** Survey measurements for tolerance control and payment purpose.
- M.** Maintenance Data: Submit manufacturer's recommended cleaning and maintenance data. Include maintenance procedures, recommended maintenance materials and suggested schedule for cleaning.

1.2 QUALITY ASSURANCE

- A.** Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B.** Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.
- C.** Testing Agency Qualifications: Demonstrate to Supervision Consultant's satisfaction, based on Supervision Consultant's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in accordance with Standards, without delaying the Work.
- D.** Surveyor Qualifications: An independent licensed surveyor, acceptable to the Supervision Consultant and experienced in ground surveys
- E.** Regulatory Requirements: Paving works shall comply with AASHTO requirements.
- F.** Preinstallation Conference: Conduct conference at Project site to comply with
- G.** General Requirements to review methods and procedures related to asphalt paving including, but not limited to, the following:
 - 1.** Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
 - 2.** Review condition of substrate and preparatory work performed by other trades.

3. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
4. Review and finalize construction schedule for paving and related work. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
5. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
6. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location and within temperature range required by manufacturer. Protect stored materials from direct sunlight.
- C. Bitumen:
 1. All transporting of bitumen shall be by conveyances that are free from contamination.
 2. The Contractor shall provide an adequate storage facility for bitumen, at the site of the mixing plant. This facility should be clean and stable and provided with cover and shelter from excessive temperatures.
 3. No open fires or smoking shall be allowed in or around the storage facility.
 4. The storage capacity should be sufficient to maintain a uniform operation while allowing for delayed shipments and time for testing.
 5. The stored bitumen products should be protected from temperatures which may exceed the range of -5°C to +60°C or as required according to flash point test as determined by AASHTO T 48.

1.4 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if substrate is wet or excessively damp, if rain is imminent or expected before time required for adequate cure or during wet weather the following conditions are not met:
 1. Prime and Tack Coats: Minimum surface temperature of 15 deg C.
 2. Slurry Coat: Comply with weather limitations in ASTM D 3910.
 3. Bituminous Binder Course: Minimum surface temperature of 15 deg C and rising at time of placement.
 4. Bituminous Wearing Course: Minimum surface temperature of 15 deg C at time of placement and when the air temperature is at or above 5 deg C.

1.5 STOCKPILING

- A.** Stockpile areas shall be surveyed prior to stockpiling to establish control points and to obtain a record of existing cross sections for future use in determining stockpile quantities. The areas shall be adequately drained at all times. Stockpiles shall be segregated by source of material. Tests on each source of material shall be conducted separately, prior to the use of the material. No mixing of the different sources shall be performed unless prior approval of the Supervision Consultant has been obtained.
- B.** Stockpiling procedures shall not result in degradation or segregation of the stockpiled material, or introduction of foreign materials into the stockpile. Heights of aggregate stockpiles shall not exceed 5 m.

1.6 SAMPLING AND TESTING

- A.** The Contractor shall submit to the Supervision Consultant, 30 days prior to the scheduled beginning of crushing and screening operations, a statement of origin and composition of all aggregates proposed for use in the Works.
- B.** In order to ascertain the properties of aggregate materials, the Contractor shall submit for testing and approval, representative samples of all materials intended for incorporation in the Works, prior to starting quarry operations. The representative samples shall be taken by the Contractor in the presence of the Supervision Consultant.
- C.** Tests performed by the Contractor shall be utilized in assessing the locations, extent of deposits and quantities of materials which will conform to the Specifications when properly processed. Any special tests that may be required by the Supervision Consultant shall be carried out by the Contractor, in his own laboratory, or an outside laboratory, approved by the Supervision Consultant.
- D.** The Contractor may conduct necessary tests in the Field Laboratory in the presence of the Supervision Consultant.
- E.** Processed materials shall be tested and approved before being stockpiled on Site or incorporated in the Works and may be inspected and tested at any time by the Supervision Consultant during their preparation, storage and use.
- F.** Samples shall satisfy all specified test requirements. The Contractor shall permit the Supervision Consultant to inspect any and all materials used or to be used, at any time during or after their preparation, or while being used during progress of the Works. Unsatisfactory materials, whether in place or not, shall be removed promptly from the Site. The Contractor shall furnish all necessary materials, labor, tools and equipment and transport required by the Supervision Consultant for such inspections.

PART 2 - PRODUCTS

2.1 AGGREGATE

- A.** Aggregates for use in bituminous binder courses, wearing courses and surface course, shall consist of crushed stone or crushed aggregate, screenings and mineral filler, with or without sand meeting the specified gradation.
- B.** Coarse aggregate shall be the fraction of crushed aggregate material retained on 4.75 mm (No. 4) sieve. Fine aggregate in accordance to AASHTO M 29 shall be the fraction of crushed aggregate material passing 4.75 mm (No. 4) sieve. Mineral filler in

accordance to AASHTO M 17 shall be added when the combined grading of coarse and fine aggregates is deficient in material passing 0.075 mm (No. 200) sieve.

- C.** The aggregates shall contain no more than 10% thin or elongated particles plus fine aggregates passing the 4.75 mm (No. 4) sieve.
- D.** Aggregates shall not contain gypsum more than 1% when tested in accordance to AASHTO T 105, and the coarse fraction of the aggregate shall not contain more than :
 - 1.** 5% chert and flint for aggregate to be used in the Wearing course.
 - 2.** 5% chert and flint for aggregate to be used in the Binder course.
- E.** Aggregates shall be of uniform quality, free from decomposed stone, organic matter, shale and any other deleterious substances.
- F.** The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T 112.
- G.** Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.
- H.** When tested for soundness in accordance with AASHTO T 104 the coarse aggregate (retained on No. 4 sieve) shall not show signs of disintegration and the loss by weight after 5 cycles shall not exceed 9% in the case of the sodium sulfate test and 12% in the case of the magnesium sulfate test.
- I.** The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion test), shall not exceed 30%.
- J.** Water absorption of the coarse aggregate as determined by BS 812 or ASTM C 128/C127 shall not exceed 2% by weight.
- K.** The flakiness index and the elongation index test should be conducted in accordance with BS 812 Part 105.1 and Part 105.2; the following are the maximum limits:

	Surface &Wearing Course	Binder Course
Flakiness Index F.I.	25	30
Elongation Index E.I.	25	30

- L.** Aggregates shall be washed if directed, to remove any clay lumps, organic matter, adherent dust or clay films or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.
- M.** Mineral filler shall consist of finely divided mineral matter such as limestone dust if added separately; hydrated lime; other non-plastic mineral filler, free from clay and organic impurities; or Portland cement, conforming to AASHTO M 17.
- N.** Aggregates shall comply with the following:
 - 1.** Acid soluble chloride: BS 812 Part 117 0.1 % max
 - 2.** Acid soluble sulphate: BS 812 Part 118 0.5 % max

- O.** Combined coarse and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T 27 and T 11, shall conform to the following requirements:

Heavy Traffic

<i>Sieve Designation</i>	<i>Binder Wearing</i>	
	Course	Course
1 1/2" ---	---	---
25.0 mm (1")	100	100
19.0 mm (3/4")	80 – 100	86 – 100
12.5 mm (1/2")	63 – 85	69 – 87
9.5 mm (3/8")	57 – 77	58 – 78
4.75 mm (No. 4)	40 – 60	40 – 60
2.36 mm (No. 8)	25 – 45	25 – 45
1.18 mm (No. 20)	13 – 27	13 – 27
0.300 mm (No. 50)	5 – 17	5 – 17
0.150 mm (No. 80)	4 – 14	4 – 14
0.075 mm (No. 200)	2 – 8	2 – 8

-
- P.** The material from hot bins passing the number 40 sieve (0.425 mm) when tested in accordance with AASHTO T 90 shall be non plastic. In addition the material from cold bins should not have PI larger than 5.
- Q.** When tested for resistance to stripping in accordance with the AASHTO T-182 at least 95% coated particles should be achieved. Scandinavian test shall be carried out and at least 60% of the coarse aggregate surface area shall remain coated with a bitumen film especially for exposed surfaces otherwise anti stripping agent must be added to achieve the required coating.
- R.** When necessary to improve the coating of aggregate by bitumen, additives of approved type will be added to the bituminous material in such percentage as required to obtain satisfactory results in the affinity, with bitumen test performed in accordance to AASHTO T 182. The approved additive will be used in accordance with Technical Specifications issued by the manufacturer and approved by the Supervision Consultant after appropriate testing.
- S.** No Extra payment will be made for required anti-stripping additives.
- T.** Material shall pass test according to AASHTO T283 "Resistance of Asphalt Concrete Mixtures to Moisture-Induced Damage".

- U. The hot bin materials shall contain a minimum 70 % sand equivalent (AASHTO T 176). Test sample shall be taken from hot bins.
- V. The Aggregate crushing value should be conducted in accordance with BS 812 part 110; the following are the maximum limits:

<u>Wearing Course</u>	<u>Binder Course</u>
Crushing value 20%	25%

- W. For hot-mix asphalt, limit natural sand to a maximum of 10 percent by weight of the total aggregate mass.

2.2 BITUMEN MATERIALS

- A. Bitumen binder penetration shall be grade 60-70 unless otherwise specified.
- B. Heating of Bitumen
 - 1. Heating equipment shall be of an approved type. Any method of agitation or heating that introduces free steam or moisture into the bitumen will not be approved.
 - 2. Tanks for heating and storage of bitumen shall be capable of heating the material, under effective and positive control at all times, to the specified temperature. The system shall provide uniform heating for the entire contents of the tank.
 - 3. Thermometers of approved type and adequate range (calibrated in 2 degrees C increments) for accurately measuring the temperature of the bitumen while heating, shall be located so as to be readily visible and shall be kept clean and in proper working order at all times.
- C. Sampling and Testing
 - 1. Procedures for sampling of bituminous materials shall conform to AASHTO T 40.
- D. Penetration Graded Bitumen
 - 1. Wherever specified, the various grades of penetration graded bitumen Asphalt cement shall conform generally to the requirements of AASHTO M 20.
 - 2. If it is required by the Supervision Consultant to use viscosity graded asphalt cement it shall meet the requirement of AASHTO M 226-80 table 1,2.
 - 3. Sampling and testing shall be in accordance with the AASHTO standard method listed in AASHTO M 20.
 - 4. Penetration bitumen application temperature range shall be so that appropriate viscosity range for each application is achieved. Application temperature shall range between 145 ° C and 165 ° C for bitumen grade 60-70.
 - 5. An approved modifier shall be incorporated in all penetration graded bitumens whenever specified immediately prior to the time of use, unless otherwise shown on the Drawings.
- E. Rapid-Curing (RC) Cutback Bitumen
 - 1. RC cutback shall conform to the requirements of AASHTO M 81.

2. Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 81.
3. RC cutback bitumen spraying temperature ranges shall be so that appropriate viscosity for each application is achieved, if however the viscosity curve are not available the values given below should be generally consider as guidance :

RC Cutback Grade	Spraying Temp. °C
RC – 70	40 – 75

F. Medium-Curing (MC) Cutback Bitumen

1. MC cutback shall conform to the requirements of AASHTO M 82.
2. Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 82.
3. MC cutback bitumen spraying temperature ranges shall be so that appropriate viscosity for each application is achieved, if however the viscosity curve are not available the values given below should be generally consider as guidance :

MC Cutback Grade	Spraying Temp. °C
MC – 30	21 – 63
MC – 70	45 – 80

G. Emulsified Bitumens

1. Selection and use of emulsified bitumens shall generally be in accordance with the recommendations in AASHTO R 5.

H. Anionic Emulsified Bitumen

1. Anionic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 140, for Type SS-1 and SS-1h.
2. Sampling and testing shall be in accordance with AASHTO T 59.
3. Emulsified bitumen spraying temperature range shall be so that appropriate viscosity for each application is achieved, if however the viscosity curves are not available these values should be generally as guidance 25 - 65 degrees C.

I. Cationic Emulsified Bitumen

1. Cationic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 208, for Types CSS-1.
2. Sampling and testing shall be in accordance with AASHTO T 59.
3. Emulsified bitumen spraying temperature range shall be so that appropriate viscosity for each application is achieved, if however the viscosity Curve are not available, these values should be generally as guidance 25-65 degrees C.

2.3 PRIME COATS

- A. Prime coats shall be medium-curing cutback asphalt, MC-30 (MC-0) or MC-70 (MC-1) as recommended by ASTM D2399-83 for open and tight surfaces.

2.4 TACK COATS

- A.** The Tack coat material shall be either rapid curing cutback asphalt RC-70 (RC-1) or slow setting emulsified asphalt SS-1, SS-1h, CSS-1, or CSS-1h.

2.5 WATER

- A.** Potable.

2.6 AUXILIARY MATERIALS

- A.** Herbicide: Commercial chemical for weed control, registered by Environmental Protection Agency (EPA). Provide granular, liquid, or wettable powder form.
- B.** Sand: AASHTO M 29 or ASTM D 1073, Grade Nos. 2 or 3.

PART 3 - EXECUTION

3.1 EXAMINATION

- A.** Verify that base course is dry and in suitable condition to support paving and imposed loads.
- B.** Proof-roll the aggregate base course using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.
- C.** Inspect surfaces on which asphalt materials are to be placed for conformance to the required compaction, grades, and sections.
- D.** Notify Supervision Consultant in writing of any unsatisfactory conditions. Do not begin paving installation until these conditions have been satisfactorily corrected.

3.2 COLD MILLING

- A.** Clean existing paving surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement, including hot-mix asphalt and, as necessary, unbound-aggregate base course, by cold milling to grades and cross sections indicated.

3.3 PATCHING AND REPAIRS

- A.** All saw-cutting and breaking of existing pavements of any type, cleaning, patching, sealing or carrying out pavement repair works shall be coordinated with the Supervision Consultant through the submission of detailed method statement for every area that needs repair. The method statement should show the extent of patching or repair works, the steps that shall be followed and the materials that shall be used for each type of repair, with due consideration to the applicability of the proposed method and materials to each specific repair case. The execution shall not start before receiving the written approval of the Supervision Consultant.
- B.** Patching: Saw cut perimeter of patch and excavate existing pavement section to sound base. Recompact new subgrade. Excavate rectangular or trapezoidal patches, extending 300 mm into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically.
 - 1.** Tack coat faces of excavation and allow to cure before paving.
 - 2.** Fill excavation with dense-graded, hot-mix asphalt base mix and, while still hot, compact flush with adjacent surface.

- 3. Partially fill excavation with dense-graded, hot-mix asphalt base mix and compact while still hot. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.
- C. Leveling Course: Install and compact leveling course consisting of dense-graded, hot-mix asphalt surface course to level sags and fill depressions deeper than 25 mm in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 75 mm thick.

- D. Crack and Joint Filling: Remove existing filler material from cracks or joints to a depth of 6 mm. Refill with asphalt joint-filling material to restore watertight condition. Remove excess filler that has accumulated near cracks or joints.

1. Tack Coat: Apply according to Article 3.6.

3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
- B. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.
- C. Remove loose materials from existing asphalt pavement and clean surface using approved mechanical sweepers, blowers, and hand brooms. Remove loose broken, or shattered asphaltic material along the edges of existing surfaces. Shape, blade, and broom the exposed subgrade and a sufficient width of shoulder to provide a uniform firm subgrade for the new surface course.
- D. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application Control of Traffic: Do not permit unnecessary traffic on the surface after it has been approved to receive asphaltic material instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

1. Mix herbicide with prime coat when formulated by manufacturer for that purpose.

- E. Control of Traffic: Do not permit unnecessary traffic on the surface after it has been approved to receive asphaltic material.

3.5 EQUIPMENT FOR SPREADING ASPHALTIC MATERIALS

- A. All equipment used for surface cleaning, heating bitumen (if required) and application of prime and tack coats, shall be adequate for the purposes intended and shall be approved before use.
- B. Equipment used for diluting emulsified bitumen, heating cutback bitumen, spraying cutback and emulsified bitumen, application of blotting material to prime coats, and for spreading asphaltic materials shall be approved by the Supervision Consultant.

3.6 PRIME AND TACK COATS

- A. The equipment used for Prime and Tack Coats shall include:

1. Power broom or a power blower or both.
2. Pressure distributor.
3. Bitumeter having a dial registering travels per minute.
4. Pump equipped with tachometer having a dial registering liters per minute passing through the nozzles.
5. Indicator, indicating accurately the temperature of the asphaltic material.
6. Spray for not less than 3.00m width, with provision for application of lesser width when necessary.
7. Hose and spray nozzles attachment for applying materials to patches and inaccessible areas.
8. The distributor shall be provided with heating attachments and the asphaltic material shall be circulated during the entire process.

B. Construction of Trial Sections

1. The Supervision Consultant may, if he deems necessary, require trial sections to be constructed prior to the commencement of on Site prime or tack coat applications. The Contractor shall construct trial sections using varying application rates of bitumen, as selected by the Supervision Consultant. Each trial section shall be 2 lanes wide by 50 m long, at approved locations on or close to the Site.
2. Each trial section shall be constructed using the same materials, mixing and spraying equipment, and construction procedures, proposed for use in the Works.
3. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment and the most suitable application rates for cutback bitumen prime and tack coats.
4. The Contractor shall not proceed with any site coat applications until the methods and procedures established in the trials have been approved.

C. Prime and Tack Coats Application - General

1. All surfaces to receive prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned using power brooms or power blowers. The surfaces shall be approved before applying any bitumen material.
2. The surfaces of all structures, curbs, gutters and other highway appurtenances shall be protected in an approved manner to prevent them from being splattered or stained with bitumen or damaged during equipment operation.
3. Application of prime coats and tack coats shall be performed only when the surface to be treated is sufficiently dry, for tack coat and sufficiently moist for prime coat, and when the atmospheric temperature is above 10°C for the application of tack coat, 15°C for the application of prime coat. There should be no fog, rain, strong winds, dusty conditions, or dust storms

4. The prime coat shall be applied only when the base meets the specified density requirements and the moisture content in the top half of the base does not exceed 90% of the optimum moisture of the base material.
5. The Contractor shall maintain prime coats and tack coats intact until they are covered by the subsequent pavement course.

D. Prime Coat Application

1. Application rates for prime coat will be determined by the Supervision Consultant from the trial sections, and shall be generally within the following ranges:

Type of Surface	ltr/sq.m
Shoulders and base	
Courses	0.5 – 1.75
Other surfaces	(determined from field tests or trials)

The surface of base course shall be lightly bladed and rolled prior to the application of prime coat. Prime coat shall be applied only when the surface is dry. A minimum period of 24 hours shall be allowed for the absorption and curing of the prime coat. The prime coat shall be applied at the rate specified above or as directed.

2. The Supervision Consultant may order additional trial sections and/or alter the previously established rates of application during progress of the Works.
3. If the moisture content of the base is too low, it shall be lightly sprinkled with water and rolled with a traffic roller before application of the primer.
4. Prime coat (MC-70) cutback, or other grade if ordered by the Supervision Consultant, shall be applied at the rate selected by the Supervision Consultant, using approved type pressure distributors operated by skilled workmen. The spray nozzles and spray bar shall be adjusted and frequently checked so that uniform distribution is ensured. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures taken before spraying is resumed.
5. Hand spraying will be approved only for priming small patches or inaccessible areas that cannot be primed by normal operation of the pressure distributor.
6. Application of prime at the junction of spreads shall not be excessive. Any excess shall be removed from the surface and any skipped areas or recognized deficiencies shall be corrected by use of hand sprays.
7. Prime coats shall be cured for 3 days before traffic is allowed on it or before the succeeding pavement layer is placed, or as directed by the Supervision Consultant.
8. If the asphalt primer has not been completely absorbed by the base twenty-four (24) hours after application, just sufficient sand shall be spread over the surface with a mechanical spreader to blot up the excess asphalt and prevent it from being picked up by traffic. Prior to placing an intermediate or surface course, all loose

sand shall be swept from the base. A hand spray shall be used to apply primer material necessary to touch up all spots unavoidably missed by the distributor

E. Tack Coat Application

1. Emulsified bitumen shall be diluted and thoroughly mixed with an equal amount of water before application.
2. The rate of application shall be approved by the Supervision Consultant and after trial tests are carried out it shall be between 0.1 and 0.6 kg/sqm., depending on whether RC cutback or emulsified bitumen is used and the surface condition of the bituminous course on which the tack coat is to be sprayed. The Supervision Consultant may alter the previously established rates of application during progress of the Works, if he deems it necessary.
3. Apply by approved pressure distributors. Spray nozzles and spray bar shall be adjusted and frequently checked to ensure uniform distribution. Stop spraying upon clogging or interference of any nozzles, and take corrective measures before resuming..
4. The tack coat shall be allowed to dry only until it is in a suitable tacky condition to receive the superimposed bituminous course. Tack coat application shall not proceed so far in advance of the following course that it dries out completely.
5. Application at the junction of spreads shall not be in excess of the specified amount. Squeegee excess from the surface and correct skipped and deficient areas by means of approved hand sprayers.
6. When approved, after the material has been applied for 48 hours and has not dried sufficiently, apply a light application of sand as blotter material. Apply blotting material sparingly and only on areas that have not dried.
7. Spraying procedures shall be as specified for prime coat application.
8. Tack coat shall be applied between the two layers of binder and first wearing course and between the first and second layer of wearing course at the rate specified in subparagraph 2 or as directed.

3.7 BITUMINOUS COURSES

A. Job Mix and Project Mix

1. No Bituminous mixture shall be manufactured until a job-mix formula based on the results of preliminary lab tests has been submitted by the Contractor and approved in writing by the Supervision Consultant. The formula shall indicate the exact proportion of bituminous material and the mix temperature..
2. The Job Mix Formula shall specify a combination of mineral aggregates including filler and bitumen (plus bitumen modifier if any) in such proportions as to produce a Job Mix which is within the limits of the specified gradation and bitumen-content ranges and which meets the Marshall test requirements.
3. The Marshall Test procedure shall be used to determine the percentage of bitumen to be incorporated in the mix. The Job Mix Formula shall take into consideration the absorption of bitumen into the aggregates. Air voids shall be

calculated in accordance with the procedure given in the Asphalt Institute Manual, MS-2.

4. In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid anti-strip agent, may be required in the Job Mix. Portland cement shall meet the requirements of AASHTO M 85. Hydrated lime shall meet the requirements of ASTM C 207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid anti-striping agent, if needed, will normally be required in the approximate range of 0.6-1.0% by weight of the bitumen, or according to the manufacturers' specifications.

5. The following composition limits by weight are to be applied:

<i>Total Aggregates</i>	96 – 93 %
<i>Asphaltic Binder</i>	4 – 7%

6. The Job Mix for bituminous binder and wearing courses shall conform to the following composition limits, as shown in Table below:

Property	Heavy Traffic	
	Binder Wearing	
1- Marshall Stability		
Minimum at 60 C (Kg)	900	1000
2-Flows (mms)	2-3.5	2-3.5
3- Voids in Mineral		
Aggregate (VMA)	13 (-1)	14 (-1)
4- Air Voids (%)	4-7	4-6
5- Stiffness (Kg/mm)	500 (Min)	500 (Min)
6-* Loss of Stability (%)	25 (Max)	25 (Max)
7-% Aggregate voids		
Filled (VFA)	65% – 72%	75% – 82%
8- Filler / Bitumen ratio	0.6-1.5	0.6-1.5

* This test to be carried out in accordance with AASHTO T 165-82.

7. Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the limits given in table below with respect to the Job Mix gradations:

Maximum variation of Project Mix from Approved Job Mix

Sieve Designation (Square openings)	Specified Tolerances
9.5mm (3/8 in.) and above	+ or – 7.0%
4.75mm (No. 4)	+ or – 5.0%
2.36mm (No. 8)	+ or – 4.0%
1.18mm (No. 16)	+ or – 4.0%
0.600mm (No. 30)	+ or – 4.0%
0.300mm (No. 50)	+ or – 4.0%
0.150mm (No. 100)	+ or – 4.0%
0.075mm (No. 200)	+ or – 2.0%
Bitumen Content	+ or – 0.3%
Temperature of Mix on discharge	+ or – 11° C of the specified mixing temperature

8. Any deviation from these limits shall be made only with the approval of the Supervision Consultant.
9. Conformance to gradation requirements will be determined on the extracted aggregate in accordance with AASHTO T 30. The bitumen content shall be determined in accordance with AASHTO T 164.
10. The percentage of Bitumen needed for job mix must vary between:
 - a. 4% – 6.5% (For binder course).
 - a. 5% – 6.5% (For wearing course) by weight in relation to total weight of aggregates
11. The Supervision Consultant will test the project mix at least twice daily during plant operation and, if necessary, direct the Contractor to readjust the plant to conform to the Job Mix Formula. If, due to differing cold feed or hot bin gradations, the Contractor cannot consistently produce a project mix meeting 'the Job Mix requirements, production shall cease, the Job Mix shall be redesigned and re-approved and the plant readjusted to produce a new Job Mix.

B. Mixing Plant

1. Bituminous mixes shall be produced in an approved type batch mixing plant of adequate size. The plant shall conform to the relevant requirements of AASHTO M 156.

2. The mixing plant shall be fully equipped to control the gradation of hot dry aggregates and of cold damp aggregates.
3. The Contractor shall systematically inspect and verify, in the presence of the Supervision Consultant, on a weekly basis and also whenever suspected, the following key operational aspects of the mixing plant:
 - a. State of repair of the screens, and their frame mountings.
 - b. Proper working of cold and hot bin gates.
 - c. Accuracy of batching scales for filler, aggregates and bitumen.
 - d. Proper working of the nozzles of the mixer bitumen sprayer.
 - e. State of repair of the paddle tips and liners of the mixer.
 - f. Thermometers in working conditions.
4. At the commencement of the Contract at least one copy of the ASTM and AASHTO (applicable copies) latest edition.

C. Spreading and Finishing Equipments

1. Bituminous courses shall be spread and finished using approved type, self-contained, power-propelled pavers of sufficient capacity.
2. The Contractor shall make available, for reference by the Supervision Consultant, the manufacturer's instruction and operating manuals for each paver intended for use.

D. Construction of Trial Sections

1. Immediately prior to finalization of the Job Mix Formula, the Contractor shall lay trial sections of the various bituminous mixes intended for use in the Works. Each trial section shall be 2 lanes widths wide (operating simultaneously), with a longitudinal cold joint, by 50 m long at approved locations on or close to the Site. The trial section shall be of the same depth as the course which it represents. Each trial section shall be laid using the same materials, proposed Job Mix, mixing, spreading and compaction plant and spreading and compaction procedures, proposed for use in the Works.
2. Each trial section shall serve as a field verification of the Job Mix design. The mix density achievable and the air voids at that density shall be determined and, if less than required, the Job Mix Formula shall be adjusted accordingly.
3. Each trial section shall also demonstrate the adequacy of hauling, spreading and compaction equipment and the suitability of the construction methods and organization proposed.
4. The equipment used in construction of the trial section shall be the same equipment to be used on the remainder of the course represented by the trial section
5. One random sample shall be taken at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. A portion of the same sample shall be tested for theoretical maximum density, aggregate gradation and

asphalt content. Four randomly selected cores shall be taken from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in AASHTO T 40. The test results shall conform to all specified requirements for work to continue. If all test results meet the specified requirements, the trial section shall remain as part of the project pavement. If test results exceed the specified tolerances, the test section shall be removed and replaced at no cost to the project and another test section shall be constructed..

6. If the initial trial section should prove to be unacceptable, the necessary adjustments to the Job Mix Formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second trial section shall then be placed. Additional trial sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

E. Mixing Procedure

1. Each aggregate ingredient shall be heated and dried such that the temperature recorded in the hot fines bin after screening shall not exceed 170 degrees C. All material heated to more than 204 deg C in storage tanks shall be rejected.
2. Immediately after heating, the aggregates shall be screened into at least 3 sizes and conveyed into separate bins ready for batching and mixing with the bitumen. Screening operations shall produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates that are reasonably uniform and will result in the production of a mix conforming to the Job Mix requirements.
3. The dried and heated aggregate and (cold) mineral filler shall be combined in the plant in the proportionate amounts as determined by the Job Mix. Just prior to bitumen entering the mixer, bitumen modifier (catalyst) or anti-stripping additive, if required, shall be thoroughly mixed with the bitumen which shall then be introduced into the pug-mill mixer in the proportionate amount determined by the Job Mix.
4. The temperature of the bitumen upon entering the pug-mill shall be within 15°C of the aggregate temperature. Unless otherwise directed, the bitumen temperature shall be as follows:

Type and Grade of Asphalt	Viscosity (centistokes)	Max. Temperature °C Immediately after discharge from Pug-mill
85 – 100 penetration	170 + or - 20	160
60 – 70 penetration	170 + or - 20	163
40 – 50 penetration	170 + or - 20	163

5. Any mix subjected to higher temperature than those shown above shall be rejected.
6. The mixing time required in order to obtain a homogeneous mix and adequate coating of the aggregates with bitumen shall be determined by the Contractor in

the presence of the Supervision Consultant. This time shall be determined whenever the source of aggregate for the mix changes.

7. In batch plants, mixing time shall begin upon entry of bitumen into the pug-mill.

F. Surface Preparation

1. Prior to placing of mixture, the surface of primed granular base course shall be cleaned of all loose dirt and other objectionable materials with a power broom..

G. Spreading and Finishing

1. The Contractor shall survey the centerline profile and crown of the existing surface or base and determine a reference grade line which will be submitted for approval.
2. Bituminous mixes shall be laid only when the air temperature is at least 5 degrees C or above when the existing surface is free from moisture, and when the weather is not foggy, rainy, dusty or excessively windy (particularly at low temperatures).
3. After completion of surface preparation, the bituminous mix shall be spread and finished true to crown and grade by approved automatically controlled bituminous pavers with string line and sensors used for accurate levelling and manually controlled paver or hand methods may be used on irregular or other sections when approved.
4. The bituminous concrete pavement shall be constructed in accordance with required thickness. Any pavement to be constructed over 80mm in thickness shall be laid in two or more courses or layers, and no one course or layer shall exceed eighty millimetres in thickness.
5. The mixture shall be placed in consecutive, adjacent strips with a minimum width of 3 m except where edge lanes require strips of lesser width. Placing shall begin along the centre line of crowned sections or on the high side of areas with a one-way slope.
6. Make surface test to check conformity with the specified crown and grade immediately after initial compression. Correct all variations by the removal or addition of materials and by continuous rolling. The finished surface shall not vary by more than the specified tolerances. After the completion of final rolling, retest the smoothness of the course. Immediately correct all humps and depressions exceeding the specified tolerances, as approved. Replace and recompact the pavement where holes are made for test purposes

H. JOINTS

1. Make joints so as to ensure thorough and continuous bond. Construct transverse construction joints in previously laid material by cutting the material back vertically for its full depth so as to expose a fresh surface. Transverse joints in one layer shall be offset by at least 600 mm from transverse joints in the previous layer. Transverse joints in adjacent lanes shall be offset a minimum of 2 m.
2. Offset longitudinal joints in successive layers not less than 300 mm.
3. Before placing the fresh mixture against a cut joint or against old pavement, spray or paint the contact surface with a thin uniform coat of liquid asphalt. Where a finishing machine is

used, make the longitudinal joint by overlapping the screed on the previously laid material for a minimum width of 25 mm and depositing a sufficient amount of material so that the joint formed will be smooth and tight.

I. COMPACTION

- 1.** Rollers shall be operated by competent and experienced operators in accordance with the manufacturer's instructions. Rollers shall be kept in operation continuously if necessary, so that all parts of the pavement receive substantially equal compaction at the time desired.
- 2.** After spreading and strike-off, and as soon as the mix conditions permit, the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted, using approved types, sizes and numbers of rollers. Rolling shall not be prolonged to the point, where cracks appear or shoving or displacement occurs.
- 3.** All rollers shall be self-propelled vibratory steel wheel, 2-axle tandem steel-tired and pneumatic-tired types, in proper operating condition, capable of reversing without backlash or tearing of the surface, and shall be operated at speeds slow enough to avoid displacement of the bituminous mix.
- 4.** Rolling shall begin as soon as the bituminous concrete will bear the roller without undue displacement.
- 5.** The speed of the rollers, rolling pattern and, in the case of vibrator rollers, the frequency and amplitude of vibration, shall be approved by the Supervision Consultant. To prevent adhesion of the mix to the rollers, the wheels shall be kept properly and lightly moistened with water. An excessive use of water will not be permitted.
- 6.** The rolling pattern, type and number of rollers shall be established by site trial so as to achieve the required compaction. The approved rolling pattern shall be followed.
- 7.** The roller shall not be permitted to stand on pavements that have not been fully compacted. Necessary precautions shall be taken to prevent the dropping of oil, grease, petrol, or other foreign matter on the pavement, either when rollers are in operation or standing.
- 8.** The compacted density shall be equal to or greater than 98% for binder course and wearing course, respectively, of the average Marshall bulk specific gravity for each day's production unless otherwise directed by the Supervision Consultant.
- 9.** Any mix that becomes loose, broken, mixed with foreign material, or which is in any way defective in finish or density, or which does not conform in all other respects with the specified requirements shall be removed, replaced with suitable material and properly finished.
- 10.** Immediately after the completion of initial rolling by the steel rollers, pneumatic-typed rolling shall begin and continue until three complete coverages are obtained. The rollers shall be self-propelled; all tyres inflated to the same pressure and shall be operated on each coverage so that each succeeding trip of the roller will overlap slightly the coverage of the preceding trip.
- 11.** The pneumatic rollers shall be operated at a maximum speed of eight 8Km/h.
- 12.** After complete rolling has been done and after the bituminous materials has cooled and set sufficiently to hold the cover material, preferably not earlier than the day following the

application of the material, the excess loose cover material along the edges shall be broomed and bladed off the shoulder to provide a distinct line along the edge of the surface.

13. Remove paved areas that are defective or contaminated with foreign materials. Remove paving course over area affected and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
14. After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
15. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

J. CONTACT SURFACES

1. Paint contact surfaces of concrete structures with a thin uniform coating of approved asphaltic material. Place asphaltic concrete uniformly high near contact surfaces so that after compaction it shall be 6 mm above the edge of such structures.

K. SAMPLING AND TESTING

1. For verification of material, moisture content, compaction, thickness etc..., the Supervision Consultant shall at all times have access to all portions of the Works and Sites. All sampling and testing of material and work shall be carried out under the direction of the Supervision Consultant.
2. Each Bitumen shipment must be accompanied by manufacturer's specifications and certificate of test results. The Supervision Consultant can, however, order check tests at any time, if considered necessary. For each bitumen shipment, penetration and softening point test shall be performed.
 - Flash point
AASHTO T48
 - Penetration
AASHTO T49
 - Softening Point
 - AASHTO T53
3. The Marshall Bulk specific gravity shall be determined in accordance with AASHTO T 166 or AASHTO T 275.
4. Resistance to Plastic Flow of Bituminous Mixture shall be determined in accordance with AASHTO T 245.
5. Loss of stability should be tested at least once every 3 working days. The result should not exceed 25% losses from the original stability.
6. Any testing which is required under the contract which cannot be carried out by the Contractor shall be carried out at the Contractor's expense at an independent laboratory which is approved by the Supervision Consultant.
7. Acceptance:

- a.** The gradation will be acceptable when variation from the approved job mix for the average of four samples is within the limits of tolerances specified.
- b.** The asphalt content will be acceptable when variation from the approved job mix for the average of four samples is within the limits of tolerances specified.
- c.** The compaction density for all bituminous courses shall be equal to or greater than 98% of the average Marshall bulk specific gravity for each day's production unless otherwise directed by the Supervision Consultant. (90% of the results shall be greater than the lower specification tolerance limit of 96.3%).
- d.** Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

8. TESTING FREQUENCY

Work Item	(A) Source of Materials	
	Required Tests (A)	Repetition Required for all Test in (A)
Materials Used in Asphalt mix (at batching plant)	1- Specific gravity and water absorption 2- Abrasion test 3- Chert content 4- Clay lumps and friable particles 5- Flaky and elongated particles 6- Soundness	Test for each source and/or When materials quality changes and/or As requested by the Supervision Consultant
Work Item	(A) Source of Materials	
	Required Tests (A)	Repetition Required for all Test in (A)
Materials Used in Asphalt mix (from hot bins)	1- Gradation 2- Specific gravity and water absorption 3- Plasticity index 4- Sand equivalent 5- Stripping with asphalt	Test for each source and/or When materials quality changes and/or As requested by the Supervision Consultant

Asphalt Mix design Each layer (At batching plant)	1- Complete mix design 2- loss of stability	For each project and/or When materials quality changes and/or When results are not consistent with the mix design results and/or As requested by the Supervision Consultant
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Work Item	(A) Source of Materials		(B) Control on Site (The Road)	
	Required Tests (A)	Repetition Required for all Test in (A)	Required Tests (B)	Repetition Required for all Tests in (B)
	<u>At Batching Plant</u>		<u>Behind Spreader</u>	
Asphalt for each layer	1- Stability 2- Flow 3- Extraction (binder content and gradation) 4- Air voids 5- Voids in mineral aggregates 6- Daily Marshall density 7- Loss of Stability	Test each 3 working days and/or Test for each batching plant and/or As requested by the Supervision Consultant	1- Stability 2- Flow 3- Extraction (binder content and gradation) 4- Air voids 5- Voids in mineral aggregates 6- Daily Marshall density	Test each working days and/or Test for each batching plant and/or As requested by the Supervision Consultant
			1- Road density and thickness (after final compaction)	Test every 800 m ²

			1- Loss of Stability	Once every 3 working days and/or As requested by the Supervision Consultant
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L. INSTALLATION TOLERANCES

- 1.** The fully compacted and completed bituminous course shall conform to the lines, grades and cross sections as shown on the Drawings.
- 2.** Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - a.** Base Course: Plus or minus 10 mm.
 - b.** Wearing Course: Plus 6 mm, no minus.
- 3.** Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 3-m straightedge applied transversely or longitudinally to paved areas:
 - a.** Base Course: 6 mm.
 - b.** Surface Course: 3 mm.
 - c.** Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 6 mm.
- 4.** The elevations of the finished course shall be checked by the Contractor in the presence of the Supervision Consultant at maximum intervals of 12.5 m, unless otherwise specified, and at intermediate points as directed.
- 5.** The tolerances on elevations of the final bituminous wearing course surface shall not exceed 6 mm above or 10 mm below the elevation shown.

3.8 FIELD QUALITY CONTROL

Testing Agency: Engage a qualified testing agency to perform tests and inspections.

Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to AASHTO T 168.

Replace and compact hot-mix asphalt where core tests were taken.

Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

DISPOSAL

Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an approved landfill.

- A. Do not allow milled materials to accumulate on-site.

7.5 Polymer-Modified, Hot-Applied Sealant

7.5.1 Material Specifications

The sealant should meet recognized standards to ensure it performs well and resists tracking by vehicle tires.

Property	Specification / Requirement
Standard	Complies with ASTM D5078 or ASTM D6690 Type II .
Type	Polymer-modified (e.g., SBS/SBR or asphalt rubber).
Softening Point	Minimum 70°C to prevent softening in summer heat.
Application Temp	Usually 160°C–190°C ; always follow the manufacturer's exact range.
Flexibility	Must pass a bend test at low temperatures (e.g., -20°F/-29°C) to prevent cracking in winter.
Crack Width Range	Effective for cracks 3 mm to 15 mm wide.

7.5.2 Application & Preparation Requirements

- Surface Preparation:** This is critical for a lasting repair.
 - Contractor shall **thoroughly clean all cracks** of all debris, vegetation, and moisture using **oil-free compressed air or a hot-air lance**. The lance also dries and heats the crack for better adhesion.
 - Do not apply if the pavement is wet or if the ambient temperature is below **4°C to 7°C**.
- Application Process:** This is where the specification you mentioned (spreading and troweling) fits in.
 - Heat the sealant to the manufacturer's specified temperature and maintain it during use. **Do not overheat or reheat material multiple times** as this degrades its properties.

- **Over banding:** For a flush fill, the crack should be filled slightly above the surface and then **immediately struck flat** with a trowel or squeegee. If an over band (a strip covering the crack) is desired, it should be applied with a specialized wand or squeegee and be kept minimal to avoid traffic pickup.
- **Traffic:** Keep traffic off the sealed cracks until the material has cooled and hardened, generally for at least **30 minutes**.