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SECTION 1 – GENERAL SPECIFICATIONS

SCOPE OF WORKS

A. Project Identification: The "Rehabilitation of stormwater canals in Baaqline, Mount Lebanon" project comprises the construction, completion and maintenance during the defects liability period of a stormwater network located in Baaqline, Mount Lebanon.

B. Scope of Works consist of the construction, completion and maintenance during the defects liability period of the stormwater network. The Work includes structural and mechanical disciplines as defined in the drawings.

C. Project will be constructed under the conditions of contract stated in the tender documents.

SECTION 1
GENERAL SPECIFICATIONS

1.1 DEFINITIONS

For the purpose of the Contract Documents the words and expressions below shall have the following meanings:

1. "Employer" means the United Nations Development Program (UNDP).

2. "Contractor" means the person whose tender has been accepted and with whom the Contract has been entered into.

3. "Engineer" means the person whose services have been engaged by UNDP to administer the Contract as provided therein, as will be notified in writing to the Contractor.

4. "Contract" means the written agreement between the Employer and the Contractor, to which these General Conditions are annexed.

5. "The Works" means the works to be executed and completed under the Contract.

6. "Temporary Works" shall include items to be constructed which are not intended to be permanent and form part of the Works.

7. "Drawings" and "Specifications" mean the Drawings and Specifications referred to in the Contract and any modification thereof or addition thereto furnished by the Engineer or submitted by the Contractor and approved in writing by the Engineer in accordance with the Contract.

8. "Bill of Quantities" is the document in which the Contractor indicates the cost of the Works, on the basis of the foreseen quantities of items of work and the fixed unit prices applicable to them.

9. "Contract Price" means the sum agreed in the Contract as payable to the Contractor for the execution and completion of the Works and for remedying of any defects therein in accordance with the Contract.

10. "Site" means the land and other places on, under, in or through which the Works or Temporary Works are to be constructed.

1.2 SINGULAR AND PLURAL

Words importing persons or parties shall include firms or companies and words importing the singular only shall also include the plural and vice versa where the context requires.

1.3 HEADINGS OR NOTES

The headings or notes in the Contract Documents shall not be deemed to be part thereof or be taken into consideration in their interpretation.

1.4 LEGAL RELATIONSHIPS

The Contractor and the sub-contractor(s), if any, shall have the status of an independent contractor vis-à-vis the Employer. The Contract Documents shall not be construed to create any contractual relationship of any kind between the Engineer and the Contractor, but the Engineer shall, in the exercise of his duties and powers under the Contract, be entitled to performance by the Contractor of its obligations, and to enforcement thereof. Nothing contained in the Contract Documents shall create any contractual relationship between the Employer or the Engineer and any subcontractor(s) of the Contractor.

1.5 GENERAL DUTIES/POWERS OF ENGINEER

The Engineer shall provide administration of Contract as provided in the Contract Documents. In particular, he shall perform the functions hereinafter described.

1. The Engineer shall be the Employer's representative vis-à-vis the Contractor during construction and until final payment is due. The Engineer shall advise and consult with the Employer. The Employer's instructions to the Contractor shall be forwarded through the Engineer. The Engineer shall have authority to act on behalf of the Employer only to the extent provided in the Contract Documents as they may be amended in writing in accordance with the Contract. The duties, responsibilities and limitations of authority of the Engineer as the Employer's representative during construction as set forth in the Contract shall not be modified or extended without the written consent of the Employer, the Contractor and the Engineer.

2. The Engineer shall visit the Site at intervals appropriate to the stage of construction to familiarize himself generally with the progress and quality of the Works and to determine in general if the Works are proceeding in accordance with the Contract Documents. On the basis of his on-site observations as an Engineer, he shall keep the Employer informed of the progress of the Works.

3. The Engineer shall not be responsible for and will not have control or charge of construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Works or the Temporary Works. The Engineer shall not be responsible for or have control or charge over the acts or omissions of the Contractor (including the Contractor's failure to carry out the Works in accordance with the Contract) and of Sub-contractors or any of their agents or employees, or

any other persons performing services for the Works, except if such acts or omissions are caused by the Engineer's failure to perform his functions in accordance with the contract between the Employer and the Engineer.

4. The Engineer shall at all times have access to the Works wherever and whether in preparation or progress. The Contractor shall provide facilities for such access so that the Engineer may perform his functions under the Contract.

5. Based on the Engineer's observations and an evaluation of the documentation submitted by the Contractor together with the invoices, the Engineer shall determine the amounts owed to the Contractor and shall issue Certificates for Payment as appropriate.

6. The Engineer shall review and approve or take other appropriate action upon the Contractor's submittals such as Shop Drawings, Product Data and Samples, but only for conformity with the design concept of the Works and with the provisions of the Contract Documents. Such action shall be taken with reasonable promptness so as to cause no delay. The Engineer's approval of a specific item shall not indicate approval of an assembly of which the item is a component.

7. The Engineer shall interpret the requirements of the Contract Documents and judge the performance thereunder by the Contractor. All interpretations and orders of the Engineer shall be consistent with the intent of and reasonably inferable from the Contract Documents and shall be in writing or in the form of drawings. Either party may make a written request to the Engineer for such interpretation. The Engineer shall render the interpretation necessary for the proper execution of the Works with reasonable promptness and in accordance with any time limit agreed upon. Any claim or dispute arising from the interpretation of the Contract Documents by the Engineer or relating to the execution or progress of the Works shall be settled as provided in Clause 1.71 of these General Conditions.

8. Except as otherwise provided in the Contract, the Engineer shall have no authority to relieve the Contractor of any of his obligations under the Contract nor to order any work involving delay in completion of the Works or any extra payment to the Contractor by the Employer, or to make any variations to the Works.

9. In the event of termination of the employment of the Engineer, the Employer shall appoint another suitable professional to perform the Engineer's duties.

10. The Engineer shall have authority to reject work which does not conform to the Contract Documents. Whenever, in his opinion, he considers it necessary or advisable for the implementation of the intent of the Contract Documents, he will have authority to require special inspection or testing of the work

whether or not such work be then fabricated, installed or completed. However, neither the Engineer's authority to act nor any reasonable decision made by him in good faith either to exercise or not to exercise such authority shall give rise to any duty or responsibility of the Engineer to the Contractor, any subcontractor, any of their agents or employees, or any other person performing services for the Works.

11. The Engineer shall conduct inspections to determine the dates of Substantial Completion and Final Completion, shall receive and forward to the Employer for the Employer's review written warranties and related documents required by the Contract and assembled by the Contractor, and shall issue a final Certificate for Payment upon compliance with the requirements of Clause 1.47 hereof and in accordance with the Contract.

12. If the Employer and Engineer so agree, the Engineer shall provide one or more Engineer's Representative(s) to assist the Engineer in carrying out his responsibilities at the site. The Engineer shall notify in writing to the Contractor and the Employer the duties, responsibilities and limitations of authority of any such Engineer's Representative(s).

1.6 CONTRACTOR'S GENERAL OBLIGATIONS/RESPONSIBILITIES

A. Obligation to Perform in Accordance with Contract

The Contractor shall execute and complete the Works and remedy any defects therein in strict accordance with the Contract, with due care and diligence and to the satisfaction of the Engineer, and shall provide all labor, including the supervision thereof, materials, Constructional Plant and all other things, whether of a temporary or permanent nature, required in and for such execution, completion and remedying of defects, as far as the necessity for providing the same is specified in or is reasonably to be inferred from the Contract. The Contractor shall comply with and adhere strictly to the Engineer's instructions and directions on any matter, touching or concerning the Works.

B. Responsibility for Site Operations

The Contractor shall take full responsibility for the adequacy, stability and safety of all site operations and methods of construction, provided that the Contractor shall not be responsible, except as may be expressly provided in the Contract, for the design or specification of the Permanent Works or of any Temporary Works prepared by the Engineer.

C. Responsibility for Employees

The Contractor shall be responsible for the professional and technical competence of his employees and will select for work under this Contract, reliable individuals who will perform effectively in the implementation of the Contract, respect local customs and conform to a high standard of moral and ethical conduct.

D. Source of Instructions

The Contractor shall neither seek nor accept instructions from any authority external to the Employer, the Engineer or their authorized representatives in connection with the performance of his services under this Contract. The Contractor shall refrain from any action which may adversely affect the Employer and shall fulfill his commitments with fullest regard for the interest of the Employer.

E. Officials Not to Benefit

The Contractor warrants that no official of the Employer has been or shall be admitted by the Contractor to any direct or indirect benefit arising from this Contract or the award thereof. The Contractor agrees that breach of this provision is a breach of an essential term of the Contract.

F. Use of Name, Emblem or Official Seal of UNDP or the United Nations

The Contractor shall not advertise or otherwise make public the fact that he is performing, or has performed services for the Employer or use the name, emblem or official seal of the Employer or the United Nations or any abbreviation of the name of the Employer or the United Nations for advertising purposes or any other purposes.

G. Confidential Nature of Documents

All maps, drawings, photographs, mosaics, plans, reports, recommendations, estimates, documents and all other data compiled by or received by the Contractor under the Contract shall be the property of the Employer, shall be treated as confidential and shall be delivered only to the duly authorized representative of the Employer on completion of the Works; their contents shall not be made known by the Contractor to any person other than the personnel of the Contractor performing services under this Contract without the prior written consent of the Employer.

1.7 ASSIGNMENT AND SUBCONTRACTING

A. Assignment of Contract

The Contractor shall not, except after obtaining the prior written approval of the Employer, assign, transfer, pledge or make other disposition of the Contract or any part thereof or of any of the Contractor's rights, claims or obligations under the Contract.

B. Subcontracting

In the event the Contractor requires the services of subcontractors, the Contractor shall obtain the prior written approval of the Employer for all such subcontractors. The approval of the Employer shall not relieve the Contractor of any of his obligations under the Contract, and the terms of any subcontract shall be subject to and be in conformity with the provisions of the Contract.

C. Assignment of Subcontractor's Obligations

In the event of a subcontractor having undertaken towards the Contractor in respect of the work executed or the goods, materials, Plant or services supplied by such subcontractor for the Works, any continuing obligation extending for a period exceeding that of the Defects Liability Period under the Contract, the Contractor shall at any time after the expiration of such Period, assign to the Employer, at the

Employer's request and cost, the benefit of such obligation for the unexpired duration thereof.

1.8 DRAWINGS

A. Custody of drawings

The drawings shall remain in the sole custody of the Employer but two (2) copies thereof shall be furnished to the Contractor free of cost. The Contractor shall provide and make at his own expense any further copies required by him. At the completion of the Works, the Contractor shall return to the Employer all drawings provided under the Contract.

B. One copy of Drawings to be kept on Site

One copy of the Drawings furnished to the Contractor as aforesaid shall be kept by the Contractor on the Site and the same shall at all reasonable times be available for inspection and use by the Engineer and by any other person authorized in writing by the Engineer.

C. Disruption of Progress

The Contractor shall give written notice to the Engineer whenever planning or progress of the Works is likely to be delayed or disrupted unless any further drawing or order, including a direction, instruction or approval, is issued by the Engineer within a reasonable time. The notice shall include details of drawing or order required and of why and by when it is required and of any delay or disruption likely to be suffered if it is late.

1.9 WORK BOOK

The Contractor shall maintain a Work Book at the Site with numbered pages, in one original and two copies. The Engineer shall have full authority to issue new orders, drawings and instructions to the Contractor, from time to time and as required for the correct execution of the Works. The Contractor shall be bound to follow such orders, drawings and instructions.

Every order shall be dated and signed by the Engineer and the Contractor, in order to account for its receipt.

Should the Contractor want to refuse an order in the Work Book, he shall so inform the Employer, through the Engineer, by means of an annotation in the Work Book made within three (3) days from the date of the order that the Contractor intends to refuse. Failure by the Contractor to adhere to this procedure shall result in the order being deemed accepted with no further possibility of refusal.

The original of the Work Book shall be delivered to the Employer at the time of Final Acceptance of the Works. A copy shall be kept by the Engineer and another copy by the Contractor.

1.10 PERFORMANCE SECURITY

1. As guarantee for his proper and efficient performance of the Contract, the Contractor shall on signature of the Contract furnish the Employer with a Performance Security issued for the benefit of the Employer. The amount and character of such security (bond or guarantee) shall be as indicated in the Contract.

2. The Performance Bond or Bank Guarantee must be issued by an acceptable insurance company or accredited bank, in the format included in Appendix I to these General Conditions, and must be valid up to twenty-eight days after issuance by the Engineer of the Certificate of Final Completion. The Performance Bond or Bank Guarantee shall be returned to the Contractor within twenty-eight days after the issuance by the Engineer of the Certificate of Final Completion, provided that the Contractor shall have paid all money owed to the Employer under the Contract.

3. If the surety of the Performance Bond or Bank Guarantee is declared bankrupt or becomes insolvent or its right to do business in the country of execution of the Works is terminated, the Contractor shall within five (5) days thereafter substitute another bond or guarantee and surety, both of which must be acceptable to the Employer.

1.11 INSPECTION OF SITE

The Contractor shall be deemed to have inspected and examined the site and its surroundings and to have satisfied himself before submitting his Tender and signing the Contract as to all matters relative to the nature of the land and subsoil, the form and nature of the Site, details and levels of existing pipe lines, conduits, sewers, drains, cables or other existing services, the quantities and nature of the work and materials necessary for the completion of the Works, the means of access to the Site, and the accommodation he may require, and in general to have himself obtained all necessary information as to risk contingencies, climatic, hydrological and natural conditions and other circumstances which may influence or affect his Tender, and no claims will be entertained in this connection against the Employer.

1.12 SUFFICIENCY OF TENDER

The Contractor shall be deemed to have satisfied himself before tendering as to the correctness and sufficiency of his Tender for the construction of the Works and of the rates and prices, which rates and prices shall, except in so far as it is otherwise provided in the Contract, cover all his obligations under the Contract and all matters and things necessary for the proper execution and completion of the Works.

1.13 PROGRAM OF WORK TO BE FURNISHED

Within the time limit specified in the Contract, the Contractor shall submit to the Engineer for his consent a detailed Program of Work showing the order of procedure and the method in which he proposes to carry out the Works. In preparing his Program of Work the Contractor shall pay due regard to the priority required by certain works. Should the Engineer, during the progress of work, require further modifications to the Program of Work, the Contractor shall review the said program. The Contractor shall also whenever required by the Engineer submit particulars in writing of the Contractor's arrangements for carrying out the Works and of the Constructional Plant and Temporary Works which the Contractor intends to supply, use or construct as the case may be. The submission of such program, or any modifications thereto, or the particulars required by the Engineer, shall not relieve the Contractor of any of his duties or obligations under the Contract nor shall the incorporation of any modification to the Program of Work either at the commencement of the contract or during its course entitle the Contractor to any additional payments in consequence thereof.

1.14 WEEKLY SITE MEETING

A weekly site meeting shall be held between the UNDP Project Coordinator or engineer, if any, the representative of the Contractor and the Engineer or the Engineer's Representative, in order to verify that the Works are progressing normally and are executed in accordance with the Contract.

1.15 CHANGE ORDERS

1. The Engineer may instruct the Contractor, with the approval of the Employer and by means of Change Orders, all variations in quantity or quality of the Works, in whole or in part, that are deemed necessary by the Engineer.
2. Processing of change orders shall be governed by clause 1.48 of these General Conditions.

1.16 CONTRACTOR'S SUPERINTENDENCE

The Contractor shall provide all necessary superintendence during the execution of the Works and as long thereafter as the Engineer may consider necessary for the proper fulfillment of the Contractor's obligations under the Contract. The Contractor or a competent and authorized agent or representative of the Contractor approved in writing by the Engineer, which approval may at any time be withdrawn, shall be constantly on the site and shall devote his entire time to the superintendence of the Works. Such authorized agent or representative shall receive on behalf of the Contractor directions and instructions from the Engineer. If the approval of such agent or representative shall be withdrawn by the Engineer, as provided in Clause 1.17 (2) hereinafter, or if the removal of such agent or representative shall be requested by the Employer under Clause 1.17(3) hereinafter, the Contractor shall as soon as it is practicable after receiving notice of such withdrawal remove the agent or representative from the Site, and replace him by another agent or representative approved by the Engineer. Notwithstanding the provision of Clause 1.17 (2) hereinafter, the Contractor shall not thereafter employ, in any capacity whatsoever, a removed agent or representative again on the Site.

1.17 CONTRACTOR'S EMPLOYEES

The Contractor shall provide and employ on the Site in connection with the execution and completion of the Works and the remedying of any defects therein:

1. Only such technical assistants as are skilled and experienced in their respective callings and such sub-agent foremen and leading hands as are competent to give proper supervision to the work they are required to supervise, and

2. Such skilled, semi-skilled, and unskilled labor as is necessary for the proper and timely execution and completion of the Works.

The Engineer shall be at liberty to object to and require the Contractor to remove forthwith from the Works any person employed by the Contractor in or about the execution or completion of the Works, who in the opinion of the Engineer is misconducting himself, or is incompetent or negligent in the proper performance of his duties, or whose employment is otherwise considered reasonably by the Engineer to be undesirable, and such person shall not be again employed on the Site without the written permission of the Engineer. Any person so removed from the Works shall be replaced as soon as reasonably possible by a competent substitute approved by the Engineer.

Upon written request by the Employer, the Contractor shall withdraw or replace from the Site any agent, representative or other personnel who does not conform to the standards set forth in paragraph (1) of this Clause. Such request for withdrawal or replacement shall not be considered as termination in part or in whole of this Contract. All costs and additional expenses resulting from any withdrawal or replacement for whatever reason of any of the Contractor's personnel shall be at the Contractor's expense.

1.18 SETTING-OUT

The Contractor shall be responsible for the true and proper setting out of the Works in relation to original points, lines and levels of reference given by the Engineer in writing and for the correctness of the position, levels, dimensions and alignment of all parts of the Works and for the provision of all necessary instruments, appliances and labor in connection therewith. If, at any time during the progress of the Works, any error shall appear or arise in the position, levels, dimensions or alignment of any part of the Works, the Contractor, on being required so to do by the Engineer, shall, at his own cost, rectify such error to the satisfaction of the Engineer.

1.19 WATCHING AND LIGHTING

The Contractor shall in connection with the Works provide and maintain at his own cost all lights, guards, fencing and watching when and where necessary or required by the Engineer or by any duly constituted authority for the protection of the Works and the materials and equipment utilized therefor or for the safety and convenience of the public or others.

1.20 CARE OF WORKS

1. From the commencement date of the Works to the date of substantial completion as stated in the Certificate of Substantial Completion, the Contractor shall take full responsibility for the care thereof and of all Temporary Works. In the event that any damage or loss should happen

   to the Works or to any part thereof or to any Temporary Works from any cause whatsoever (save and except as shall be due to Force Majeure as defined in Clause 1.66 of these General Conditions), the Contractor shall at his own cost repair and make good the same so that, at completion, the Works shall be in good order and condition and in conformity in every respect with the requirements of the Contract and the Engineer's instructions. The Contractor shall also be liable for any damage to the Works occasioned by him in the course of any operations carried out by him for the purpose of complying with his obligations Clause 1.47 hereof.

2. The Contractor shall be fully responsible for the review of the Engineering design and details of the Works and shall inform the Employer of any mistakes or incorrectness in such design and details which would affect the Works.

1.21 INSURANCE OF WORKS, ETC.

Without limiting his obligations and responsibilities under Clause 1.20 hereof, the Contractor shall insure immediately following signature of this Contract, in the joint names of the Employer and the Contractor (a) for the period stipulated in Clause 1.20(1) hereof, against all loss or damage from whatever cause arising, other than cause of Force majeure as defined in clause 1.66 of these General Conditions, and (b) against loss or damage for which the Contractor is responsible, in such manner that the Employer and the Contractor are covered for the period stipulated in Clause 1.20 (1) hereof and are also covered during the Defects Liability Period for loss or damage arising from a cause occurring prior to the commencement of the Defects Liability Period and for any loss or damage occasioned by the Contractor in the course of any operations carried out by him for the purpose of complying with his obligations under Clause 1.47 hereof:

1. The Works, together with the materials and Plant for incorporation therein, to their full replacement cost, plus an additional sum of ten (10) per cent of such replacement cost, to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature;

2. The Contractor's equipment and other things brought on to the Site by the Contractor to the replacement value of such equipment and other things;

3. An insurance to cover the liabilities and warranties of Section 52(4);

Such insurance shall be effected with an insurer and in terms approved by the Employer, which approval shall not be unreasonably withheld, and the Contractor shall, whenever required, produce to the Engineer the policy or policies of insurance and the receipts for payment of the current premiums.

1.22 DAMAGE TO PERSONS AND PROPERTY

The Contractor shall (except if and so far as the Contract provides otherwise) indemnify, hold and save harmless and defend at his own expense the Employer, its officers, agents, employees and servants from and against all suits, claims, demands, proceedings, and liability of any nature or kind, including costs and expenses, for injuries or damages to any person or any property whatsoever which may arise out of or in consequence of acts or omissions of the Contractor or its agents, employees, servants or subcontractors in the execution of the Contract. The provision of this Clause shall extend to suits, claims, demands, proceedings and liability in the nature of workmen's compensation claims and arising out of the use of patented inventions and devices. Provided always that nothing herein contained shall be deemed to render the Contractor liable for or in respect of or with respect to:

1. The permanent use or occupation of land by the Works or any part thereof;

2. The right of the Employer to construct the Works or any part thereof on, over, under, or through any land.

3. Interference whether temporary or permanent with any right of light, airway or water or other easement or quasi-easement which is the unavoidable result of the construction of the Works in accordance with the Contract.

4. Death, injuries or damage to persons or property resulting from any act or neglect of the Employer, his agents, servants or other contractors, done or committed during the validity of the Contract.

1.23 LIABILITY INSURANCE

A. Obligation to take out Liability Insurance

Before commencing the execution of the Works, but without limiting his obligations and responsibility under Clause 1.20 hereof, the Contractor shall insure against his liability for any death, material or physical damage, loss or injury which may occur to any property, including that of the Employer or to any person, including any employee of the Employer by or arising out of the execution of the Works or in the carrying out of the Contract, other than due to the matters referred to in the proviso to Clause 1.22 hereof.

B. Minimum Amount of Liability Insurance

Such insurance shall be effected with an insurer and in terms approved by the Employer, which approval shall not be unreasonably withheld, and for at least the amount specified in the contract. The Contractor shall, whenever required by the Employer or the Engineer, produce to the Engineer the policy or policies of insurance and the receipts for payment of the current premiums.

C. Provision to Indemnify Employer

The insurance policy shall include a provision whereby, in the event of any claim in respect of which the Contractor would be entitled to receive indemnity under the policy, being brought or made against the Employer, the insurer shall indemnify the Employer against such claims and any costs, charges and expenses in respect thereof.

1.24 ACCIDENT OR INJURY TO WORKMEN

The Employer shall not be liable for or in respect of any damages or compensation payable at law in respect or in consequence of any accident or injury to any workman or other person in the employment of the Contractor or any sub-Contractor, save and except an accident or injury resulting from any act or default of the Employer, his agents or servants. The Contractor shall indemnify, hold and save harmless the Employer against all such damages and compensation, save and except as aforesaid, and against all claims, proceedings, costs, charges and expenses whatsoever in respect thereof or in relation thereto.

Insurance against Accident, etc., to Workmen

The Contractor shall insure against such liability with an insurer approved by the Employer, which approval shall not be unreasonably withheld, and shall continue such insurance during the whole of the time that any persons are employed by him for the Works and shall, when required, produce to the Engineer such policy of insurance and the receipt for payment of the current premium. Provided always that, in respect of any persons employed by any subcontractor, the Contractor's obligation to insure as aforesaid under this sub-clause shall be satisfied if the subcontractor shall have insured against the liability in respect of such persons in such manner that the Employer is indemnified under the policy but the Contractor shall require such subcontractor to produce to the Engineer when required such policy of insurance and the receipt for the current premium, and obtain the insertion of a provision to that effect in its contract with the subcontractor.

1.25 REMEDY ON CONTRACTOR'S FAILURE TO INSURE

If the Contractor shall fail to effect and keep in force any of the insurances referred to in Clauses 1.21, 23 and 24 hereof, or any other insurance which he may be required to effect under the terms of the Contract, the Employer may in any such case effect and keep in force any such insurance and pay such premium as may be necessary for that purpose and from time to time deduct the amount so paid by the Employer as aforesaid from any monies due or which may become due to the Contractor, or recover the same as a debt due from the Contractor.

1.26 COMPLIANCE WITH STATUTES, REGULATIONS, ETC.

The Contractor shall give all notices and pay all fees and charges required to be given or paid by any national or State Statutes, Ordinances, Laws, Regulations or By-laws, or any local or other duly constituted authority in relation to the execution of the Works or of any Temporary Works and by the Rules and Regulations of all public bodies and companies whose property or rights are affected or may be affected in any way by the Works or any Temporary Works.

The Contractor shall conform in all respects with any such Statutes, Ordinances, Laws, Regulations, By-laws or requirements of any such local or other authority which may be applicable to the Works and shall keep the Employer indemnified against all penalties and liabilities of every kind for breach of any such Statutes, Ordinances, Laws, Regulations, Bylaws or requirements.

1.27 FOSSILS, ETC.

All fossils, coins, articles of value or antiquity and structures and other remains or things of geological or archaeological interest discovered on the Site of the Works shall as between the

Employer and the Contractor be deemed to be the absolute property of the Employer and the Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing or damaging any such article or thing and shall immediately upon discovery thereof and before removal acquaint the Employer of such discovery and carry out at the expense of the Employer the Engineer's orders as to the disposal of the same.

1.28 COPYRIGHT, PATENT AND OTHER PROPRIETARY RIGHTS, AND ROYALTIES

The Contractor shall hold harmless and fully indemnify the Employer from and against all claims and proceedings for or on account of infringement of any patent rights, design trademark or name or other protected rights in respect of any Plant, equipment, machine, work or material used for or in connection with the Works or Temporary Works and from and against all claims, demands proceedings, damages, costs, charges and expenses whatsoever in respect thereof or in relation thereto, except where such infringement results from compliance with the design or Specification provided by the Engineer.

Except where otherwise specified, the Contractor shall pay all tonnage and other royalties, rent and other payments or compensation, if any, for getting stone, sand, gravel, clay or other materials required for the Works or Temporary Works.

1.29 INTERFERENCE WITH TRAFFIC AND ADJOINING PROPERTIES

All operations necessary for the execution of the Works and for the Construction of any Temporary Works shall, so far as compliance with the requirements of the Contract permits, be carried on so as not to interfere unnecessarily or improperly with the public convenience, or the access to, use and occupation of, public or private roads and footpaths to or of properties whether in the possession of the Employer or of any other person. The Contractor shall hold harmless and indemnify the Employer in respect of all claims, demands,

proceedings, damages, costs, charges and expenses whatsoever arising out of or in relation to any such matters in so far as the Contractor is responsible therefor.

1.30 EXTRAORDINARY TRAFFIC AND SPECIAL LOADS

The Contractor shall use every reasonable means to prevent any of the roads or bridges communicating with or on the routes to the Site from being damaged by any traffic of the Contractor or any of his sub-contractors and, in particular, shall select routes, choose and use vehicles and restrict and distribute loads so that any such extraordinary traffic as will inevitably arise from the moving of plant and material from and to the Site shall be limited as far as reasonably possible and so that no unnecessary damage may be occasioned to such roads and bridges.

Should it be found necessary for the Contractor to move any load of Constructional Plant, machinery, pre-constructed units or parts of units of work, or other thing, over part of a road or bridge, the moving whereof is likely to damage any such road or bridge unless special protection or strengthening is carried out, then the Contractor shall before moving the load on to such road or bridge, save insofar as the Contract otherwise provide, be responsible for and shall pay for the cost of strengthening any such bridge or altering or improving any such road to avoid such damage, and the Contractor shall indemnify and keep the Employer indemnified against all claims for damage to any such road or bridge caused by such movement, including such claim as may be made directly against the Employer, and shall negotiate and pay all claims arising solely out of such damage.

1.31 OPPORTUNITIES FOR OTHER CONTRACTORS

The Contractor shall in accordance with the requirements of the Engineer afford all reasonable opportunities for carrying out their work to any other contractors employed by the Employer and their workmen and to the workmen of the Employer and of any other duly constituted authorities who may be employed in the execution on or near the Site of any work not included in the Contract or of any contract which the Employer may enter into in connection with or ancillary to the Works. If work by other contractors of the Employer as above-mentioned involves the Contractor in any direct expenses as a result of using his Site facilities, the Employer shall consider payment to the Contractor of such sum or sums as may be recommended by the Engineer.

1.32 CONTRACTOR TO KEEP SITE CLEAN

During the progress of the Works, the Contractor shall keep the Site reasonably free from all unnecessary obstruction and shall store or dispose of any Constructional Plant and surplus materials and clear away and remove from the Site any wreckage, rubbish or Temporary Works no longer required.

1.33 CLEARANCE OF SITE ON SUBSTANTIAL COMPLETION

On the substantial completion of the Works, the Contractor shall clear away and remove from the Site all Constructional Plant surplus materials, rubbish and Temporary Works of every kind and leave the whole of the Site and Works clean and in a workmanlike condition to the satisfaction of the Engineer.

1.34 LABOR

A. Engagement of Labor

The Contractor shall make his own arrangements for the engagement of all labor local or otherwise.

B. Supply of Water

The Contractor shall provide on the Site to the satisfaction of the Engineer an adequate supply of drinking and other water for the use of the Contractor's staff and work people.

C. Alcoholic Drinks or Drugs

The Contractor shall comply with Government laws and regulations and orders in force as regards the import, sale, barter or disposal of alcoholic drinks or narcotics and he shall not allow or facilitate such importation, sale, gift, barter or disposal by his sub-contractors, agents or employees.

D. Arms and Ammunition

The restrictions specified in clause 1.34-C above shall include all kinds of arms and ammunition.

E. Holiday and Religious Customs

The Contractor shall in all dealings with labor in his employ have due regard to all holiday, recognized festivals and religious or other customs.

F. Epidemics

In the event of any outbreak of illness of an epidemic nature the Contractor shall comply with and carry out such regulations, orders, and requirements as may be made by the Government or the local medical or sanitary authorities for the purpose of dealing with and overcoming the same.

G. Disorderly Conduct, etc.

The Contractor shall at all times take all reasonable precautions to prevent any unlawful riotous or disorderly conduct by or amongst his employees and for the preservation of peace and the protection of persons and property in the neighborhood of the Works against the same.

H. Observance by Sub-Contractors

The Contractor shall be considered responsible for the observance of the above provisions by his Sub-Contractors.

I. Legislation applicable to Labor

The Contractor shall abide by all applicable legislation and regulation with regard to labor.

1.35 RETURNS OF LABOR, PLANT, ETC.

The Contractor shall, if required by the Engineer, deliver to the Engineer at his office, a return in detail in the form and at such intervals as the Engineer may prescribe showing the supervisory staff and the numbers of the several classes of labor from time to time employed by the Contractor on the Site and such information respecting Constructional plant as the Engineer may require.

1.36 MATERIALS, WORKMANSHIP AND TESTING

A. Materials and Workmanship

All materials and workmanship shall be of the respective kinds described in the Contract and in accordance with the Engineer's instructions and shall be subjected from time to time to such tests as the Engineer may direct at the place of manufacture or fabrication, or on the Site or at all or any of such places. The Contractor shall provide such assistance, instruments, machines, labor and materials as are normally required for examining, measuring and testing any work and the quality, weight or quantity of any materials used and shall supply samples of materials before incorporation in the Works for testing as may be selected and required by the Engineer. All testing equipment and instruments provided by the Contractor shall be used only by the Engineer or by the Contractor in accordance with the instructions of the Engineer.

No material not conforming with the Specifications in the Contract may be used for the Works without prior written approval of the Employer and instruction of the Engineer, provided always that if the use of such material results or may result in increasing the Contract Price, the procedure in Clause 1.48 shall apply.

B. Cost of Samples

All samples shall be supplied by the Contractor at his own cost unless the supply thereof is clearly intended in the Specifications or Bill of Quantities to be at the cost of the Employer. Payment will not be made for samples which do not comply with the Specifications.

C. Cost of Tests

The Contractor shall bear the costs of any of the following tests:

1. Those clearly intended by or provided for in the Contract Documents.

2. Those involving load testing or tests to ensure that the design of the whole of the Works or any part of the Works is appropriate for the purpose which it was intended to fulfill.

1.37 ACCESS TO SITE

The Employer and the Engineer and any persons authorized by either of them shall, at all times, have access to the Works and to the Site and to all workshops and places where work is being prepared or whence materials, manufactured articles or machinery are being obtained for the Works and the Contractor shall afford every facility for and every assistance in or in obtaining the right to such access.

1.38 EXAMINATION OF WORK BEFORE COVERING UP

No work shall be covered up or put out of view without the approval of the Engineer and the Contractor shall afford full opportunity for the Engineer to examine and measure any work which is about to be covered up or put out of view and to examine foundations before permanent work is placed thereon. The Contractor shall

give due notice to the Engineer whenever any such work or foundations is or are ready or about to be ready for examination and the Engineer shall without unreasonable delay unless he considers it unnecessary and advises the Contractor accordingly attend for the purpose of examining and measuring such work or of examining such foundations.

1.39 REMOVAL OF IMPROPER WORK AND MATERIALS

A. Engineer's power to order removal

The Engineer shall during the progress of the Works have power to order in writing from time to time, and the Contractor shall execute at his cost and expense, the following operations:

1. The removal from the Site within such time or times as may be specified in the order of any materials which in the opinion of the Engineer are not in accordance with the Contract;

2. The substitution of proper and suitable materials; and the removal and proper re-execution (notwithstanding any previous test thereof or interim payment therefore) of any work which in respect of materials or workmanship is not in the opinion of the Engineer in accordance with the Contract.

B. Default of Contractor in carrying out Engineer's Instructions

In case of default on the part of the Contractor in carrying out an instruction of the Engineer, the Employer shall be entitled to employ and pay other persons to carry out the same and all expenses consequent thereon or incidental thereto shall be borne by the Contractor and shall be recoverable from him by the Employer and may be deducted by the Employer from any monies due or which may become due to the Contractor.

1.40 SUSPENSION OF WORK

The Contractor shall on the written order of the Engineer suspend the progress of the Works or any part thereof for such time or times and in such manner as the Engineer may consider necessary and shall, during such suspension, properly protect and secure the Works so far as it is necessary in the opinion of the Engineer. The Employer should be notified and his written approval should be sought for any suspension of work in excess of three (3) days.

1.41 POSSESSION OF SITE

A. Access to Site

The Employer shall with the Engineer's written order to commence the Works, give to the Contractor possession of so much of the Site as may be required to enable the Contractor to commence and proceed with the construction of the Works in accordance with the Program referred to in Clause 1.13 hereof and otherwise in accordance with such reasonable proposals of the Contractor as he shall make to the Engineer by notice in writing, and shall from time to time as the Works proceed give to the Contractor possession of such further

portions of the Site as may be required to enable the Contractor to proceed with the construction of the Works with due dispatch in accordance with the said Program or proposals, as the case may be.

B. Wayleaves, etc.

The Contractor shall bear all expenses and charges for special temporary wayleaves required by him in connection with access to the Site. The Contractor shall also provide at his own cost any additional accommodation outside the Site required by him for the purpose of the Works.

C. Limits of the Site

Except as defined below, the limits of the Site shall be as defined in the Contract. Should the Contractor require land beyond the Site, he shall provide it entirely at his own expense and before taking possession shall supply the Engineer with a copy of the necessary permits. Access to the Site is available where the Site adjoins a public road but it is not provided unless shown on the Drawings. When necessary for the safety and convenience of workmen, public or livestock or for the protection of the Works, the Contractor shall, at his own expense, provide adequate temporary fencing to the whole or part of the Site. The Contractor shall not disturb, damage or pull down any hedge, tree or building within the Site without the written consent of the Engineer.

1.42 TIME FOR COMPLETION

Subject to any requirement in the Contract as to completion of any section of the Works before completion of the whole, the whole of the Works shall be completed, in accordance with the provisions of Clause 1.46 and 47 hereof, within the time stated in the Contract.

The completion time includes weekly rest days, official holidays, and days of inclement weather.

1.43 EXTENSION OF TIME FOR COMPLETION

If, subject to the provisions of the Contract, the Engineer orders alterations or additions in the Works in accordance with Clause 1.48 hereof, or if circumstances constituting force majeure as defined in the Contract have occurred, the Contractor shall be entitled to apply for an extension of the time for completion of the Works specified in the Contract. The Employer shall, upon such application, determine the period of any such extension of time; provided that in the case of alterations or additions in the Works, the application for such an extension must be made before the alterations or additions in the Works are undertaken by the Contractor.

1.44 RATE OF PROGRESS

The whole of the materials, plant and labor to be provided by the Contractor and the mode, manner and speed of execution and completion of the Works are to be of a kind and conducted in a manner to the satisfaction of the Engineer. Should the rate of progress of the works or any part thereof be at any time in the opinion of the engineer too slow to ensure the completion of the Works by the prescribed time or extended time for completion, the Engineer shall so notify the Contractor in writing and the Contractor shall thereupon take

such steps as the Contractor may think necessary and the Engineer may approve to expedite progress so as to complete the Works by the prescribed time or extended time for completion. If the work is not being carried on by day and by night and the Contractor shall request permission to work by night as well as by day, then, if the Engineer shall grant such permission, the Contractor shall not be entitled to any additional payment. All work at night shall be carried out without unreasonable noise and disturbance. The contractor shall indemnify the Employer from and against any claims or liability for damages on account of noise or other disturbance created while or in carrying out the work and from and against all claims, demands, proceedings, costs and expenses whatsoever in regard or in relation to such noise or other disturbance. The Contractor shall submit in triplicate to the Engineer at the end of each month signed copies of explanatory Drawings or any other material showing the progress of the Works.

1.45 LIQUIDATED DAMAGES FOR DELAY

If the Contractor shall fail to complete the Works within the time for completion prescribed in the Contract, or any extended time for completion in accordance with the Contract, then the Contractor shall pay to the Employer the sum specified in the Contract as liquidated damages, for the delay between the time prescribed in the Contract or the extended time for completion, as the case may be, and the date of substantial completion of the Works as stated in the Certificate of Substantial Completion, subject to the applicable limit stated in the Contract. The said sum shall be payable by the sole fact of the delay without the need for any previous notice or any legal proceedings, or proof of damage, which shall in all cases be considered as ascertained. The Employer may, without prejudice to any other method of recovery, deduct the amount of such liquidated damages from any monies in its hands due or which may become due to the Contractor. The payment or deduction of such damages shall not relieve the Contractor from his obligation to complete the Works or from any other of his obligations and liabilities under the Contract.

If, before the time for completion of the whole of the Works or of a Section of the Works, a Certificate of Substantial Completion has been issued for any part or Section of the Works, the liquidated damages for delay in completion of the remainder of the Works or of that Section may, for any period of delay after the date stated in such Certificate of Substantial Completion, and in the absence of alternative provisions in the Contract, be reduced in the proportion which the value of the part or Section so certified bears to the total value of the whole of the Works or Section, as applicable. The provisions of this Sub-Clause shall only apply to the rate of liquidated damages and shall not affect the limit thereof.

1.46 CERTIFICATE OF SUBSTANTIAL COMPLETION

A. Substantial Completion of the Works

When the whole of the Works have been substantially completed and have satisfactorily passed any test on completion prescribed by the Contract, the Contractor may give a notice to that effect to the Engineer accompanied by an undertaking to finish any outstanding work during the Defects Liability Period. Such notice and undertaking shall be in writing and shall be deemed to be a request by the Contractor, for the Engineer to issue a Certificate of Substantial Completion in respect of the Works. The Engineer shall, within twenty-one (21) days of the date of delivery of such notice either issue to the Contractor, with a copy to the Employer, a Certificate of Substantial Completion stating the date on which, in his opinion, the Works were substantially completed in accordance with the Contract or give instructions in writing to the Contractor

specifying all the work which, in the Engineer's opinion, requires to be done by the Contractor before the issuance of such Certificate. The Engineer shall also notify the Contractor of any defects in the Works affecting substantial completion that may appear after such instructions and before completion of the work specified therein. The Contractor shall be entitled to receive such Certificate of Substantial Completion within twenty-one (21) days of completion, to the satisfaction of the Engineer, of the work so specified and making good any defect so notified. Upon issuance of the Certificate of Substantial Completion of the Works, the Contractor shall be deemed to have undertaken to complete with due expedition any outstanding work during the Defects Liability Period.

B. Substantial Completion of Sections or Parts of the Works

In accordance with the procedure in Sub-Clause (1) of this Clause and on the same conditions as provided therein, the Contractor may request the Engineer to issue, and the Engineer may issue, a Certificate of Substantial Completion in respect of any Section or part of the Works which has been substantially completed and has satisfactorily passed any tests on completion prescribed by the Contract, if:

1. A separate time for completion is provided in the Contract in respect of such Section or part of the Works;

2. Such Section or part of the Works has been completed to the satisfaction of the Engineer and is required by the Employer for his occupation or use.

Upon the issuance of such Certificate, the Contractor shall be deemed to have undertaken to complete any outstanding work during the Defects Liability Period.

1.47 DEFECTS LIABILITY

A. Defects Liability Period

The expression "Defects Liability Period" shall mean the period of twelve (12) months, calculated from the date of completion of the Works stated in the Certificate of Substantial Completion issued by the Engineer or, in respect of any Section or part of the Works for which a separate Certificate of Substantial Completion has been issued, from the date of completion of that Section or part as stated in the relevant Certificate. The expression "the Works" shall, in respect of the Defects Liability Period, be construed accordingly.

B. Completion of Outstanding Work and Remedying of Defects

During the Defects Liability Period, the Contractor shall finish the work, if any, outstanding at the date of the Certificate of Substantial Completion, and shall execute all such work of repair, amendment, reconstruction, rectification and making good defects, imperfections, shrinkages or other faults as may be required of the Contractor in writing by the Engineer during the Defects Liability Period and within fourteen (14) days after its expiration, as a result of an inspection made by or on behalf of the Engineer prior to expiration of the Defects Liability Period.

C. Cost of Execution of Work of Repair, etc.

All such outstanding work shall be carried out by the Contractor at his own expense if the necessity thereof shall, in the opinion of the Engineer, be due to the use of material or workmanship not in accordance with the Contract, or to neglect or failure on the part of the Contractor to comply with any obligation expressed or implied, on the Contractor's part under the Contract.

D. Remedy on Contractor's Failure to Carry Out Work Required

If the Contractor shall fail to do any such work outstanding on the Works, the Employer shall be entitled to employ and pay other persons to carry out the same, and all expenses consequent thereon or incidental thereto shall be recoverable from the Contractor by the Employer, and may be deducted by the Employer from any monies due or which may become due to the Contractor.

E. Certificate of Final Completion

Upon satisfactory completion of the work outstanding on the Works, the Engineer shall within twenty eight (28) days of the expiration of the Defects Liability period issue a Certificate of Final Completion to the Contractor. The Contract shall be deemed to be completed upon issuance of such Certificate, provided that the provisions of the Contract which remain unperformed and the Settlement of Disputes provision in the Contract shall remain in force for as long as is necessary to dispose of any outstanding matters or issues between the Parties.

1.48 ALTERATIONS, ADDITIONS AND OMISSIONS

A. Variations

The Engineer may within his powers introduce any variations to the form, type or quality of the Works or any part thereof which he considers necessary and for that purpose or if for any other reasons it shall, in his opinion be desirable, he shall have power to order the Contractor to do and the Contractor shall do any of the following:

1. Increase or decrease the quantity of any work under the Contract;

2. Omit any such work;

3. Change the character or quality or kind of any such work;

4. Change the levels, lines, positions and dimensions of any part of the Works;

5. Execute additional work of any kind necessary for the completion of the Works, and no such variation shall in any way vitiate or invalidate the Contract.

B. Variations Increasing Cost of Contract or altering the Works

The Engineer shall, however, obtain the written approval of the Employer before giving any order for any variations which may result in an increase of the Contract Price or in an essential alteration of the quantity, quality or character of the Works.

C. Orders for Variations to be in Writing

No variations shall be made by the Contractor without an order in writing from the Engineer. Variations requiring the written approval of the Employer under paragraph (2) of this Clause shall be made by the Contractor only upon written order from the Engineer accompanied by a copy of the Employer's approval. Provided that, subject to the provisions of the Contract, no order in writing shall be required for any increase or decrease in the quantity of any work where such increase or decrease is not the result of an order given under this Clause but is the result of the quantities exceeding or being less than those stated in the Bill of Quantities.

D. Valuation of Variations

The Engineer shall estimate to the Employer the amount to be added or deducted from the Contract Price in respect of any variation, addition or omission. In the case of any variation, addition or omission which may result in an increase of the Contract Price, the Engineer shall communicate such estimate to the Employer together with his request for the Employer's written approval of such variation, addition or omission. The value of any variation, addition or omission shall be calculated on the basis of the unit prices contained in the Bill of Quantities.

1.49 PLANT, TEMPORARY WORKS AND MATERIALS

A. Plant, etc., Exclusive Use for the Works

All Constructional Plant, Temporary Works and Materials provided by the Contractor shall, when brought on the Site, be deemed to be exclusively intended for the construction and completion of the Works and the Contractor shall not remove the same or any part thereof (save for the purpose of moving it from one part of the Site to another) without the consent in writing of the Engineer which shall not be unreasonably withheld.

B. Removal of Plant, etc.

Upon completion of the Works the Contractor shall remove from the Site all the said Constructional Plant and Temporary Works remaining thereon and any unused materials provided by the Contractor.

C. Employer not liable for Damage to Plant

The Employer shall not be at any time liable for the loss of any of the said Constructional plant, Temporary Works or Materials save if such loss results from the act or neglect of the Employer, its employees or agents.

D. Ownership of paid material and work

All material and work covered by payments made by the Employer to the Contractor shall thereupon become the sole property of the Employer, but this provision shall not be construed as relieving the Contractor from the sole responsibility for all material and work upon which payments have been made or the restoration of any damaged work or as waiving the right of the Employer to require the fulfillment of all of the terms of the Contract.

E. Equipment and supplies furnished by Employer

Title to any equipment and supplies which may be furnished by the Employer shall rest with the Employer and any such equipment and supplies shall be returned to the Employer at the conclusion of the Contract or when no longer needed by the Contractor. Such equipment when returned to the Employer, shall be in the same condition as when delivered to the Contractor, subject to normal wear and tear.

1.50 APPROVAL OF MATERIALS ETC., NOT IMPLIED

The operation of Clause 1.49 hereof shall not be deemed to imply any approval by the Engineer of the materials or other matters referred to therein nor shall it prevent the rejection of any such materials at any time by the Engineer.

1.51 MEASUREMENT OF WORKS

The Engineer shall, when he requires any part or parts of the Works to be measured, give notice to the Contractor or the Contractor's authorized agent or representative who shall forthwith attend or send a qualified agent to assist the Engineer in making such measurement and shall furnish all particulars required by either of them. Should the Contractor not attend or neglect or omit to send such agent, then the measurement made by the Engineer or approved by him shall be taken to be the correct measurement of the work. The purpose of measuring is to ascertain the volume of work executed by the Contractor and therefore determine the amount of the monthly payments.

1.52 LIABILITY OF THE PARTIES

The Works shall not be considered as completed until a Certificate of Final Completion shall have been signed by the Engineer and delivered to the Employer stating that the Works have been completed and that the Contractor has fulfilled all his obligations under Clause 1.47 to his satisfaction.

The Employer shall not be liable to the Contractor for any matter arising out of or in connection with the Contract or the execution of the Works unless the Contractor shall have made a claim in writing in respect thereof before the giving of the Certificate of Final Completion and in accordance with the Contract.

A. Unfulfilled Obligations

Notwithstanding the issue of the Certificate of Final Completion, the Contractor shall remain liable for the fulfillment of any obligation incurred under the provisions of the Contract prior to the issuance of the Certificate of Final Completion and which remains unperformed at the time such Certificate is issued. For the purpose of determining the nature and extent of any such obligation the Contract shall be deemed to remain in force between the parties hereto.

B. Contractor Responsible

Notwithstanding any other provisions in the Contract documents, the Contractor shall be totally responsible for and shall bear any and all risks of loss or damage to or failure of the Works or any part thereof for a period of ten years after issuance of the Certificate of Final Completion, provided always that such risks, damage or failure result from acts, defaults and negligence of the Contractor, his agents, employees or workmen and such contractors.

1.53 AUTHORITIES

The Employer shall have the right to enter upon the Site and expel the Contractor therefrom without thereby voiding the Contract or releasing the Contractor from any of his obligations or liabilities under the Contract or affecting the rights and powers conferred on the Employer and the Engineer by the Contract in any of the following cases:

1. If the Contractor is declared bankrupt or claims bankruptcy or court protection against his creditors or if the Contractor is a company or member of a company which was dissolved by legal action;

2. If the Contractor makes arrangements with his creditors or agrees to carry out the Contract under an inspection committee of his creditors;

3. If the Contractor withdraws from the Works or assigns the Contract to others in whole or in part without the Employer's prior written approval;

4. If the Contractor fails to commence the Works or shows insufficient progress to the extent which in the opinion of the Engineer will not enable him to meet the target completion date of the Works;

5. If the Contractor suspends the progress of the Works without due cause for fifteen (15) days after receiving from the Engineer written notice to proceed;

6. If the Contractor fails to comply with any of the Contract conditions or fails to fulfill his obligations and does not remedy the cause of his failure within fifteen (15) days after being notified to do so in writing;

7. If the Contractor is not executing the work in accordance with standards of workmanship specified in the Contract;

8. If the Contractor gives or promises to give a present or loan or reward to any employee of the Employer or of the Engineer.

Then the Employer may himself complete the Works or may employ any other contractor to complete the Works and the Employer or such other contractor may use for such completion so much of Constructional Plant, Temporary Works and Materials, which have been deemed to be reserved exclusively for the construction and completion of the Works under the provision of the Contract as he or they may think proper and the Employer may at any time sell any of the said Constructional Plant, Temporary Works and unused materials and apply the proceeds of sale in or towards the satisfaction of any sums due or which may become due to him from the Contractor under the Contract.

A. Evaluation after Re-entry

The Engineer shall as soon as may be practicable after any such entry and expulsion by the Employer notify the Contractor to attend the necessary evaluation of the Works. In the event that for any reason the Contractor does not attend such evaluation the Engineer shall undertake the said evaluation in the absence of the Contractor and shall issue a certificate stating the sum, if any, due to the Contractor for work done in accordance with the Contract up to the time of entry and expulsion by the Employer which has been reasonably accumulated to the Contractor in respect of the Works he has executed in such case in accordance with the Contract. The Engineer shall indicate the value of the materials whether unused or partially used and the value of construction equipment and any part of the Temporary Works.

B. Payment after Re-entry

If the Employer shall enter and expel the Contractor under this Clause he shall not be liable to pay the Contractor any money on account of the Contract until the expiration of the Defects Liability Period, and thereafter until the costs of completion and making good any defects of the Works, damages for delay in completion (if any), and all other expenses incurred by the Employer have been ascertained and their amount certified by the Engineer.

The Contractor shall then be entitled to receive only such sum or sums (if any) as the Engineer may certify would have been due to him upon due completion by him after deducting the said amount. But if such amount shall exceed the sum which would have been payable to the Contractor on due completion by him, then the Contractor shall upon demand pay to the Employer the amount of such excess. The Employer in such case may recover this amount from any money due to the Contractor from the Employer without the need to resort to legal procedures.

1.54 URGENT REPAIRS

If by reason of any accident or failure or other event occurring to, in or in connection with the Works or any part thereof either during the execution of the Works or during the Defects Liability Period any remedial or other work or repair shall in the opinion of the Engineer be urgently necessary for security and the Contractor is unable or unwilling at once to do such work or repair, the Employer may by his own or other workmen do such work or repair as the Engineer may consider necessary. If the work or repair so done by the Employer is work which in the opinion of the Engineer the Contractor was liable to do at his own expense under the Contract, all costs and charges properly incurred by the Employer in so doing shall on demand be paid by the Contractor to the Employer or may be deducted by the Employer from any monies due or which may become due to the Contractor provided always that the Engineer shall as soon after the occurrence of any such emergency as may be reasonably practicable notify the Contractor thereof in writing.

1.55 INCREASE AND DECREASE OF COSTS

Except if otherwise provided by the Contract, no adjustment of the Contract Price shall be made in respect of fluctuations of market, prices of labor, materials, plant or equipment, neither due to fluctuation in interest rates nor devaluation or any other matters affecting the Works.

1.56 TAXATION

The Contractor shall be responsible for the payment of all charges and taxes in respect of income including value added tax, all in accordance with and subject to the provisions of the income tax laws and regulations in force and all amendments thereto. It is the Contractor's responsibility to make all the necessary inquiries in this respect and he shall be deemed to have satisfied himself regarding the application of all relevant tax laws.

1.57 BLASTING

The Contractor shall not use any explosives without the written permission of the Engineer who shall require that the Contractor has complied in full with the regulations in force regarding the use of explosives. However, the Contractor, before applying to obtain these explosives, has to provide well-arranged storage facilities. The Engineer's approval or refusal to permit the use of explosives shall not constitute ground for claims by the Contractor.

1.58 MACHINERY

The Contractor shall be responsible for coordinating the manufacture, delivery, erection and commissioning of plant machinery and equipment which are to form a part of the Works. He shall place all necessary orders as soon as possible after the signing of the Contract. These orders and their acceptance shall be produced to the Engineer on request. The Contractor shall also be responsible for ensuring that all sub-contractors adhere to such programs as are agreed and are needed to ensure completion of the Works within the period for completion. Should any sub-contracted works be delayed, the Contractor shall initiate the necessary action to speed up such completion. This shall not prejudice the Employer's right to exercise his remedies for delay in accordance with the Contract.

1.59 TEMPORARY WORKS AND REINSTATEMENT

The Contractor shall provide and maintain all temporary roads and tracks necessary for movement of plant and materials and clear same away at completion and make good all works damaged or disturbed. The Contractor shall submit drawings and full particulars of all Temporary Works to the Engineer before commencing same. The Engineer may require modifications to be made if he considers them to be insufficient and the Contractor shall give effect to such modifications but shall not be relieved of his responsibilities. The Contractor shall provide and maintain weather-proof sheds for storage of material pertinent to the Works both for his own use and for the use of the Employer and clear same away at the completion of the Works. The Contractor shall divert as required, at his own cost and subject to the approval of the Engineer, all public utilities encountered during the progress of the Works, except those specially indicated on the drawings as being included in the Contract. Where diversions of services are not required in connection with the Works, the Contractor shall uphold, maintain and keep the same in working order in existing locations. The Contractor shall make good, at his own expense, all damage to telephone, telegraph and electric cable or wires, sewers, water or other pipes and other services, except where the Public Authority or Private Party

owning or responsible for the same elects to make good the damage. The costs incurred in so doing shall be paid by the Contractor to the Public Authority or Private Party on demand.

1.60 PHOTOGRAPHS AND ADVERTISING

The Contractor shall not publish any photographs of the Works or allow the Works to be used in any form of advertising whatsoever without the prior approval in writing from the Employer.

1.61 PREVENTION OF CORRUPTION

The Employer shall be entitled to cancel the Contract and to recover from the Contractor the amount of any loss resulting from such cancellation, if the Contractor has offered or given any person any gift or consideration of any kind as an inducement or reward for doing or intending to do any action in relation to the obtaining or the execution of the Contract or any other contract with the Employer or for showing or intending to show favor or disfavor to any person in relation to the Contract or any other contract with the Employer, if the like acts shall have been done by any persons employed by him or acting on his behalf whether with or without the knowledge of the Contractor in relation to this or any other Contract with the Employer.

1.62 DATE FALLING ON HOLIDAY

Where under the terms of the Contract any act is to be done or any period is to expire upon a certain day and that day or that period fall on a day of rest or recognized holiday, the Contract shall have effect as if the act were to be done or the period to expire upon the working day following such day.

1.63 NOTICES

Unless otherwise expressly specified, any notice, consent, approval, certificate or determination by any person for which provision is made in the Contract Documents shall be in writing. Any such notice, consent, approval, certificate or determination to be given or made by the Employer, the Contractor or the Engineer shall not be 2 unreasonably withheld or delayed.

1. Any notice, certificate or instruction to be given to the Contractor by the Engineer or the Employer under the terms of the Contract shall be sent by post, cable, telex or facsimile at the Contractor's principal place of business specified in the Contract or such other address as the Contractor shall nominate in writing for that purpose, or by

2. Delivering the same at the said address against an authorized signature certifying the receipt.

3. Any notice to be given to the Employer under the terms of the Contract shall be sent by post, cable, telex or facsimile at the Employer's address specified in the Contract, or by delivering the same at the said address against an authorized signature certifying the receipt.

4. Any notice to be given to the Engineer under the terms of this Contract shall be sent by post, cable, telex or facsimile at the Engineer's address specified in the Contract, or by delivering the same at the said address against an authorized signature certifying the receipt.

1.64 LANGUAGE, WEIGHTS AND MEASURES

Except as may be otherwise specified in the Contract, English shall be used by the Contractor in all written communications to the Employer or the Engineer with respect to the services to be rendered and with respect to all documents procured or prepared by the Contractor pertaining to the Works. The metric system of weights and measures shall be used in all instances.

1.65 RECORDS, ACCOUNTS, INFORMATION AND AUDIT

The Contractor shall maintain accurate and systematic records and accounts in respect of the work performed under this Contract.

The Contractor shall furnish, compile or make available at all times to the UNDP any records or information, oral or written, which the UNDP may reasonably request in respect of the Works or the Contractor's performance thereof.

The Contractor shall allow the UNDP or its authorized agents to inspect and audit such records or information upon reasonable notice.

1.66 FORCE MAJEURE

Force majeure as used herein means Acts of God, war (whether declared or not), invasion, revolution, insurrection or other acts or events of a similar nature or force.

In the event of and as soon as possible after the occurrence of any cause constituting force majeure, the Contractor shall give notice and full particulars in writing to the UNDP and to the Engineer of such force majeure if the Contractor is thereby rendered unable, wholly or in part, to perform its obligations and meet its responsibilities under this Contract. Subject to acceptance by the UNDP of the existence of such force majeure, which acceptance shall not be unreasonably withheld, the following provisions shall apply:

1. The obligations and responsibilities of the Contractor under this Contract shall be suspended to the extent of his inability to perform them and for as long as such inability continues. During such suspension and in respect of work suspended, the Contractor shall be reimbursed by the UNDP substantiated costs of maintenance of the Contractor's equipment and of per diem of the Contractor's permanent personnel rendered idle by such suspension;

2. The Contractor shall within fifteen (15) days of the notice to the UNDP of the occurrence of the force majeure submit a statement to the UNDP of estimated costs referred to in subparagraph (a) above during the period of suspension followed by a complete statement of actual expenditures within thirty (30) days after the end of the suspension;

3. The term of this Contract shall be extended for a period equal to the period of suspension taking however into account any special condition which may cause the additional time for completion of the Works to be different from the period of suspension;

4. If the Contractor is rendered permanently unable, wholly or in part, by reason of force majeure, to perform his obligations and meet his responsibilities under the Contract, the UNDP shall have the right to terminate the Contract on the same terms and conditions as provided for in Clause 1.68 of these General Conditions, except that the period of notice shall be seven (7) days instead of fourteen (14) days, and

5. For the purpose of the preceding sub-paragraph, the UNDP may consider the Contractor permanently unable to perform in case of any suspension period of more than ninety (90) days.

1.67 SUSPENSION BY THE UNDP

The UNDP may by written notice to the Contractor suspend for a specified period, in whole or in part, payments to the Contractor and/or the Contractor's obligation to continue to perform the Works under this Contract, if in the UNDP' sole discretion:

1. Any conditions arise which interfere, or threaten to interfere with the successful execution of the Works or the accomplishment of the purpose thereof, or

2. The Contractor shall have failed, in whole or in part, to perform any of the terms and conditions of this Contract.

After suspension under sub-paragraph above, the Contractor shall be entitled to reimbursement by the UNDP of such costs as shall have been duly incurred in accordance with this Contract prior to the commencement of the period of such suspension.

The term of this Contract may be extended by the UNDP for a period equal to any period of suspension, taking into account any special conditions which may cause the additional time for completion of the Works to be different from the period of suspension.

1.68 TERMINATION BY THE UNDP

The UNDP may, notwithstanding any suspension under Clause 1.67 above, terminate this Contract for cause or convenience in the interest of the UNDP upon not less than fourteen (14) days written notice to the Contractor.

Upon termination of this Contract:

1. The Contractor shall take immediate steps to terminate his performance of the Contract in a prompt and orderly manner and to reduce losses and to keep further expenditures to a minimum, and

2. The Contractor shall be entitled (unless such termination has been occasioned by the Contractor's breach of this Contract), to be paid for the part of the Works satisfactorily completed and for the materials and equipment properly delivered to the Site as of the date of termination for incorporation to the Works, plus substantiated costs resulting from commitments entered into prior to the date of termination as well as any reasonable substantiated direct costs incurred by the Contractor as a result of the termination, but shall not be entitled to receive any other or further payment or damages.

1.69 TERMINATION BY THE CONTRACTOR

In the case of any alleged breach by the UNDP of the Contract or in any other situation which the Contractor reasonably considers to entitle him to terminate his performance of the Contract, the Contractor shall promptly give written notice to the UNDP detailing the nature and the circumstances of the breach or other situation. Upon acknowledgement in writing by the UNDP of the existence of such breach and the UNDP' inability to remedy it, or upon failure of the UNDP to respond to such notice within twenty (20) days of receipt thereof, the Contractor shall be entitled to terminate this Contract by giving 30 days written notice thereof. In the event of disagreement between the Parties as to the existence of such breach or other situation referred to above, the matter shall be resolved in accordance with Clause 1.71 of these General Conditions.

Upon termination of this Contract under this Clause the provisions of sub-paragraph (b) of Clause 1.68 hereof shall apply.

1.70 RIGHTS AND REMEDIES OF THE UNDP

Nothing in or relating to this Contract shall be deemed to prejudice or constitute a waiver of any other rights or remedies of the UNDP.

The UNDP shall not be liable for any consequences of, or claim based upon, any act or omission on the part of the Government.

1.71 SETTLEMENT OF DISPUTES

In the case of any claim, controversy or dispute arising out of, or in connection with this Contract or any breach thereof, the following procedure for resolution of such claim, controversy or dispute shall apply.

A. Notification

The aggrieved party shall immediately notify the other party in writing of the nature of the alleged claim, controversy or dispute, not later than seven (7) days from awareness of the existence thereof.

B. Consultation

On receipt of the notification provided above, the representatives of the Parties shall start consultations with a view to reaching an amicable resolution of the claim, controversy or dispute without causing interruption of the Works.

C. Conciliation

Where the representatives of the Parties are unable to reach such an amicable settlement, either party may request the submission of the matter to conciliation in accordance with the UNCITRAL Rules of Conciliation then obtaining.

D. Arbitration

Any claim, controversy or dispute which is not settled as provided under clauses 1.71 - A through C above shall be referred to arbitration in accordance with the UNCITRAL Arbitration Rules then obtaining. The Parties shall be bound by the arbitration award rendered in accordance with such arbitration as the final adjudication of any such controversy or claim.

1.72 PRIVILEGES AND IMMUNITIES

Nothing in or relating to this Contract shall be deemed a waiver of any of the privileges and immunities of the United Nations of which the UNDP is an integral part.

1.73 SECURITY

The Contractor shall:

1. Put in place an appropriate security plan and maintain the security plan, taking into account the security situation in the country where the services are being provided;
2. Assume all risks and liabilities related to the Contractor's security, and the full implementation of the security plan.

UNDP reserves the right to verify whether such a plan is in place, and to suggest modifications to the plan when necessary. Failure to maintain and implement an appropriate security plan as required hereunder shall be deemed a breach of this contract. Notwithstanding the foregoing, the Contractor shall remain solely responsible for the security of its personnel and for UNDP's property in its custody as set forth in paragraph 4.1 above.

1.74 AUDIT AND INVESTIGATIONS

Each invoice paid by UNDP shall be subject to a post-payment audit by auditors, whether internal or external, of UNDP or the authorized agents of the UNDP at any time during the term of the Contract and for a period of three (3) years following the expiration or prior termination of the Contract. The UNDP shall be entitled to a refund from the Contractor for any amounts shown by such audits to have been paid by the UNDP other than in accordance with the terms and conditions of the Contract. Should the audit determine that any funds paid by UNDP have not been used as per contract clauses, the company shall reimburse such funds forthwith. Where the company fails to reimburse such funds, UNDP reserves the right to seek recovery and/or to take any other action as it deems necessary.

The Contractor acknowledges and agrees that, at anytime, UNDP may conduct investigations relating to any aspect of the Contract, the obligations performed under the Contract, and the operations of the Contractor generally. The right of UNDP to conduct an investigation and the Contractor's obligation to comply with such an investigation shall not lapse upon expiration or prior termination of the Contract. The Contractor shall provide its full and timely cooperation with any such inspections, post-payment audits or investigations.

Such cooperation shall include, but shall not be limited to, the Contractor's obligation to make available its personnel and any documentation for such purposes and to grant to UNDP access to the Contractor's premises. The Contractor shall require its agents, including, but not limited to, the Contractor's attorneys, accountants or other advisers, to reasonably cooperate with any inspections, post-payment audits or investigations carried out by UNDP hereunder.

1.75 ANTI-TERRORISM

The Contractor agrees to undertake all reasonable efforts to ensure that none of the UNDP funds received under this Contract are used to provide support to individuals or entities associated with terrorism and that the recipients of any amounts provided by UNDP hereunder do not appear on the list maintained by the Security Council Committee established pursuant to resolution 1267 (1999). The list can be accessed via http://www.un.org/Docs/sc/committees/1267/1267ListEng.htm. This provision must be included in all sub-contracts or sub-agreements entered into under this Contract.

APPENDIX I: FORMATS OF PERFORMANCE SECURITY

PERFORMACE BANK GUARANTEE

To:.....

[INSERT FULL NAME AND ADDRESS OF RR or BUREAU/DIVISION

DIRECTOR AT UNDP]

WHEREAS.....[INSERT NAME AND

ADDRESS OF THE CONTRACTOR] (hereinafter called "the Contractor") has undertaken, in pursuance of Contract No....., dated....., to

execute.....[INSERT TITLE OF CONTRACT AND BRIEF DESCRIPTION OF WORKS], (hereinafter called "the Contract");

AND WHEREAS it has been stipulated by you in the said Contract that the Contractor shall furnish you with a Bank Guarantee by a recognized Bank for the sum specified therein as security for compliance with his obligations in accordance with the Contract;

AND WHEREAS we have agreed to give the Contractor such a Bank Guarantee;

NOW THEREFORE we hereby irrevocably affirm that we are the Guarantor and responsible to you, on behalf of the Contractor, up to a total of.....[INSERT AMOUNT

OF GUARANTEE IN FIGURES AND IN WORDS], such sum being payable in the types and proportions of currencies in which the Contract Price is payable, and we undertake to pay you, upon your first written demand and without cavil or argument, any sum or sums within the limits of .....[INSERT AMOUNT OF GUARANTEE] as aforesaid without your needing to prove or to show grounds or reasons for your demand for the sum specified therein.

We hereby waive the necessity of your demanding the said debt from the Contractor before presenting us with the demand.

We further agree that no change or addition to or other modification of the terms of the Contract or of the Works to be performed thereunder or of any of the Contract Documents which may be made between you and the Contractor shall in any way release us from any liability under this guarantee, and we hereby waive notice of any such change, addition or modification.

This guarantee shall be valid until twenty eight calendar days after issuance of the Certificate of Final Completion.

SIGNATURE AND SEAL OF THE GUARANTOR

....

NAME OF BANK .....

ADDRESS .....

DATE .....

PERFORMANCE BOND

By this Bond .....[INSERT NAME

AND ADDRESS OF THE CONTRACTOR] as Principal (hereinafter called "the Contractor") and .....[INSERT

NAME, LEGAL TITLE AND ADDRESS OF SURETY, BONDING COMPANY OR

INSURANCE COMPANY] as Surety (hereinafter called "the Surety") are held and firmly bound unto .....[INSERT NAME AND ADDRESS OF EMPLOYER] as Obligee (hereinafter called "the Employer") in the amount of.

.....[INSERT AMOUNT OF BOND IN FIGURES AND IN WORDS], for the payment of which sum well and truly to be made in the types and proportions of currencies in which the Contract Price is payable, the Contractor and the Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

WHEREAS the Contractor has entered into a contract with the Employer dated for

..... [INSERT TITLE OF CONTRACT AND BRIEF

DESCRIPTION OF THE WORKS] in accordance with the documents, plans, specifications and amendments thereto, which to the extent herein provided for, are by reference made part hereof and are hereinafter referred to as the Contract.

NOW, THEREFORE, the Condition of this Obligation is such that, if the Contractor shall promptly and faithfully perform the said Contract (including any amendments thereto) then this obligation shall be null and void; otherwise it shall remain in full force and effect. Whenever the Contractor shall be, and declared by the Employer to be, in default under the Contract, the Employer having performed the Employer's obligations thereunder, the Surety may promptly remedy the default, or shall promptly:

1. complete the Contract in accordance with its terms and conditions; or

2. obtain a bid or bids from qualified Bidders for submission to the Employer for completing the Contract in accordance with its terms and conditions, and upon determination by the Employer and the Surety of the lowest responsible Bidder, arrange for a Contract between such Bidder and Employer and make available as work progresses (even though there should be a default or a succession of defaults under the Contract or Contracts of completion arranged under this paragraph) sufficient funds to pay the cost of completion less the Balance of the Contract Price; but not exceeding, including other costs and damages for which the Surety may be liable hereunder, the amount set forth in the first paragraph hereof. The term " Balance of the Contract Price", as used in this paragraph, shall mean the total

amount payable by Employer to Contractor under the Contract, less the amount properly paid by Employer to Contractor; or

3. Pay the Employer the amount required by Employer to complete the Contract in accordance with its terms and conditions up to a total not exceeding the amount of this Bond.

The Surety shall not be liable for a greater sum than the specified penalty of this Bond.

No right of action shall accrue on this Bond to or for the use of any person or corporation other than the Employer named herein or the heirs, executors, administrators, successors and assigns of the Employer.

In testimony whereof, the Contractor has hereunto set his hand and affixed his seal, and the Surety has caused these presents to be sealed with his corporate seal duly attested by the signature of his legal representative, this.....day of.....2000

SIGNED ON: SIGNED ON:

ON BEHALF OF: ON BEHALF OF:

NAME &TITLE: NAME &TITLE:

SECTION 2: EARTHWORKS

SECTION 2: EARTHWORKS

SECTION 2.01 REMOVAL OF PAVEMENT

2.01.1 SCOPE

This item shall consist of removing existing pavement constructions, flexible and rigid, and all other pavement items, the disposal of such material and the cutting by mechanical saws of neat lines between areas to be removed and areas not to be removed, all as directed by the Engineer.

2.01.2 GENERAL

A.. Areas designated for removal of existing pavement shall be determined by the Engineer.

B. The method of removal shall be one which is acceptable to the Engineer. Every effort shall be made to remove only the pavement layers within the limits and depth designated.

C. The manner and location of disposal for materials shall be subject to approval by the Engineer.

2.01.3 METHOD OF EXECUTION

C.1 Milling

Refer to Division 3, Section 3.06 where removal of pavement by milling is clearly specified. For depth exceeding 5 cm, a heavy duty milling machine, able to mill in one pass up to 10 cm depth, should be exclusively used by the Contractor.

C.2 Grubbing and Excavation

The Contractor may remove the pavement by any mean such excavating and grubbing if requirements related to pavement layers are not specific in this regard.
If aggregate layers are to be maintained, the Contractor should following the asphaltic pavement removal, properly reinstate these aggregate layers by providing, spreading and compacting aggregate base and sub base course for reinstatement and releveling, as specified in relevant Section.

2.01.4 MEASUREMENT

A. Pavement

Measurement and payment shall be made per linear meter for removal of asphaltic pavement. Thickness to be measured before the removal.

This rate shall be full compensation for furnishing all labour, equipment, tools, transport, depositing, and incidentals necessary to complete the item, including required reinstatement and rectification of existing aggregate layers at the Contractor 's cost.

SECTION 2.02 REMOVAL OF OBSTRUCTIONS AND UTILITIES

2.02.1 SCOPE

The work covered in this Section consists of the removal, wholly or in part, and satisfactory disposal of all buildings, fences, structures, abandoned pipelines, existing roadways, sidewalks, kerbs, signs, bollards, electricity columns, advertising signs and any other obstructions, which are not designated or permitted to remain. This Section also covers rerouting, relocating or diverting utilities, fencing, signs and other feature obstructing the Works, salvaging of designated materials and backfilling the resulting trenches, holes and pits.

2.02.2 GENERAL

A. The Contractor shall examine the Site and record all obstructions and utilities at the commencement of the Works. Examination shall include (but not be limited to) surveying, identification, collection of data from organisations, authorities and others, exploratory pits and trial trenching. The Engineer shall decide if obstructions and utilities not discovered at the commencement of the Works and that subsequently require removal, diversion or replacement shall be directly paid for or the costs considered covered under the Contact.

B. Any information or data, whether expressed or implied, obtained by the Contractor with respect to the existence or location of obstructions or utilities above or below ground shall neither be construed nor deemed to construe any passing of responsibility to the Employer or the Engineer for the correctness, accuracy, validity or use of any such information and data. The Contractor shall be solely responsible for his own assessment, interpretation and evaluation thereof and have made due allowance in his Tender for risks, contingencies and all other circumstances which may influence or affect the undertaking of the Works. This information shall be obtained without prejudice to the Contractor's obligation to inspect the Site prior to submitting his Tender, pursuant to sub-clause 11.1 of the Conditions of Contract.

C. The Engineer shall decide whether materials to be removed from the area are salvageable, perishable or non- perishable.

2.02.3 CONSTRUCTION

A General

A.1 The Contractor shall raze, remove and dispose of all buildings, foundations, structures, fences and other obstructions which are fully or partly on the ROW, except for utilities and other items for which alternative arrangements for removal have been made.

A.2 All salvageable material including steel bridges, lighting poles, electricity columns, ductile iron pipes, water supply lines, traffic signs, advertising signs, overhead signs and panels, bollards and any other material designated to be salvaged shall be removed, without causing unnecessary damage in sections or pieces and shall be transported and stored by the Contractor at locations instructed or approved by the Engineer or detailed on the Drawings, for later use or for collection by others as directed by the Engineer.

A.3 Unusable perishable material shall be destroyed. Non-perishable material may be disposed of off the Site, provided permission of the respective property owners has been obtained in writing to dispose of such materials on their land.

A.4 Salvaged pipe culverts and other re-usable structures shall be stored at accessible locations on Site, as approved by the Engineer, and shall become the property of the Employer.

B. Demolition of Existing Buildings and Structures

B.1 Demolition or partial demolition of existing buildings and structures adjacent to or within the works shall be carried out as indicated on the Drawings or as directed by the Engineer. Such demolition includes building foundations and supporting works to a uniform depth of 300 mm below the lowest foundation level.

B.2 Prior to carrying out the demolition or partial demolition of buildings or structures, the Contractor shall submit to the Engineer a method statement containing, but not limited to, the following:

- A schedule for disconnection, capping and/or continuation of utility services as required.
- A detailed sequence of demolition and removal work to ensure uninterrupted progress of other site operations.
- Proposals for the temporary diversion of traffic, pedestrian access and protection measures in accordance with the Safety, Health and Environmental regulations.
- Proposals for the partial demolition, making good and rehabilitation of buildings that are to be partly demolished by the Contactor as indicated on the Drawings.

B.3 Buildings and structures shall be vacated and decommissioned prior to start of demolition work.

B.4 Where buildings are to be partially demolished and/or reinstated by the property owner, the Contractor shall liaise with and coordinate his works as necessary to facilitate these demolition and reinstatement works.

B.5 Materials of salvable value to Contractor shall be removed from buildings and structures as work progresses. Salvaged items shall be transported from site as they are removed to storage as directed by the Engineer. Salvaged materials remain the property of the Employer, unless otherwise designated by the Engineer.

B.6 Demolition operations and removal of debris shall be carried out by methods that ensure minimum interference with roads, streets, footways and other adjacent occupied or used facilities

B.7 Roads, streets and footways shall only be closed with the Local Authority's consent Alternative routes around closed or obstructed traffic ways shall be provided unless otherwise indicated on the Drawings or instructed by the Engineer

B.8 The Contractor shall take the following into account to ensure the safe passage of persons and to prevent damage to adjacent around demolition areas.

- The provision of temporary covered passageways.
- Interior and exterior shoring, bracing or support to prevent movement, settlement or collapse of structures to be demolished and adjacent properties or other facilities.

B.9 Accidental damage caused to adjacent buildings, structures and other features by demolition operations shall be promptly repaired at no cost to the Contract and to the satisfaction of the Engineer.

B.10 Existing utilities shall be maintained in service and protected against damage during demolition operations.

B.11 Demolition work shall not commence until all utility disconnections have been completed and verified by the Engineer.

B.12 The Contractor shall take all necessary measures to control pollution arising from demolition works. Dust emissions shall be controlled by the use of water sprinkling, temporary enclosures and other suitable methods

B.13 Adjacent buildings, structures and other features shall be cleaned to remove dust, dirt and debris caused by demolition operations, as directed by Engineer, to return adjacent areas to their condition existing prior to the start of demolition work.

B.14 Foundations shall be removed to a depth of not less than 300 mm below the existing ground surface unless otherwise shown on the Drawings or instructed by the Engineer .All wood, metal and flooring shall be removed.

B.15 Basements or cavities left by structure removal shall be filled to the level of the surrounding ground and, if within the construction area, shall be compacted to the type of compaction within the range for the adjacent roadway embankment as specified in Section 2.06 - Embankment Construction.

B.16 Prior to placement of fill material, all areas to be filled shall be free of standing water, frost, frozen material, trash and debris.

B.17 Fill materials shall be placed in horizontal uncompacted layers not exceeding 250 mm. Each layer shall be compacted at the optimum moisture content of the fill material to a density equal to original adjacent ground unless subsequent excavation for

new work is required.

B.18 After fill placement and compaction is complete the Contractor shall grade the surface to meet adjacent contours and to provide flow to surface drainage.

C. Removal of Bridges, Culverts and Ditches

C.1 Bridges, culverts and other drainage structures in locations traversed by traffic shall not be removed until arrangements to the Engineer's approval have been made by the Contractor to maintain the flow of traffic.

C.2 Substructures of bridges, culverts and other drainage structures shall be removed down to the profile of the watercourse. Substructure away from the watercourse shall be removed to a depth of 300 mm below the adjacent natural ground surface. Where sections of existing structures lie wholly or partly within the limits for a new structure they shall be removed to the extent necessary to accommodate construction of the proposed structure.

C.3 Steel and timber bridges designated to be salvaged shall be dismantled without causing any damage. Steel members shall be match- marked and all salvaged material shall be inventorised, transported and delivered to designated areas or as directed by the Engineer. The Contractor shall submit a detailed method statement for the dismantling, removal and storage of the bridge structure for the Engineer's approval.

C.4 Blasting or other operations which are necessary for removal of existing structures or obstructions shall be completed prior to commencing any new construction in the vicinity.

C.5 Necessary safety measures shall be taken by the Contractor during all blasting operations to avoid injury to persons and damage to properties or to the finished work. A comprehensive Safety Method Statement shall be presented to the Engineer for approval prior to the start of blasting. Regardless of the Engineer's approval, blasting or other operations shall be performed at the entire risk and responsibility of the Contractor.

C.6 Where necessary or directed by the Engineer, the Contractor shall provide heavy mesh blasting mats for protection of persons, properties and the Works. If, in the opinion of the Engineer, blasting would be dangerous to persons or adjacent structures, or is being carried out in an unsafe or unacceptable manner, he shall prohibit subsequent blasting and instruct the Contractor to carry out the demolition works by alternative methods.

C.7 The Contractor shall make good the affected area following the removal of bridges, culverts and ditches to the satisfaction of the Engineer.

D. Removal of Pipes

All pipes, unless otherwise directed by the Engineer, shall be removed and precautions taken to avoid breaking or damaging the pipes. The Contractor shall exercise the utmost care during the removal of pipes to avoid unnecessary damage.

E. Removal of Rocks and Boulders

Large rocks and boulders of individual sizes greater than 0.2 m^3 or 500 kg lying within the limits of the Works shall be removed and disposed of as indicated on the Drawings or directed by the Engineer.

F. Removal of Fences, Walls and Gates

When fences, walls and gates enclosing properties and fields are to be removed, the Contractor shall notify the Engineer sufficiently in advance to give the property owner reasonable notice to make suitable arrangements, including temporary fencing and livestock relocation..

G. Removal of Wells

Existing wells, abandoned or active, which lie within the limits of the Works, shall be dismantled, backfilled, and compacted. All salvageable materials shall be removed and stored at locations on Site approved by the Engineer. All salvageable material shall become the property of the Employer. Wells shall be filled to the level of the surrounding ground and, if within the limits of construction, shall be compacted in accordance with the Drawings or as instructed by the Engineer.

H. Removal of Trees

Removal or transplanting of existing trees with a girth of less than one metre shall be carried out in accordance with the provisions of Section 2.01: Clearing and Grubbing. Trees with a girth of over one metre shall be felled by a suitably qualified tree surgeon approved by the Engineer and the stump and roots removed to a depth of 1.5 metres. The resulting timber and roots shall be disposed of in accordance with the Engineer's instructions.

I. Removal of Existing Utilities

I.1 The locations of existing utilities shall be investigated and established by the Contractor in consultation with the relevant Authority or Service Provider.

I.2 Any utility which has been damaged in the course of the work shall be replaced with equivalent materials, to the satisfaction of the Engineer and relevant Authority or Service Provider, by the Contractor at his own expense.

I.3 Any action taken by the Contractor with respect to power cables, telephone cables and water mains encountered during the course of the work, shall comply with the requirements of the responsible Authority and at his own expense

I.4 The Contractor shall coordinate with the Engineer and notify all Utility Owners and co-operate with them in respect of removal, rerouting, relocating and diverting utilities.

I.5 Enabling, relocating, rerouting and diverting utilities shall be carried out by the Contractor unless indicated otherwise in the Contract Documents or instructed by the Engineer. Works shall be executed in close coordination with the respective utility owner or service provider, including provision for inspection, salvaging of materials, connections and reconnections.

I.6 The Contractor shall coordinate with the Engineer and shall advise each affected Utility Owner in writing of his proposed construction schedule.

I.7 The Contractor shall be responsible for supporting and protecting realigned utilities and existing utilities that are to remain in place for the duration of the Contract and shall provide all necessary Temporary Works in this respect. Any damage caused to utilities and attributable to the Contractor shall be repaired at his expense, including any fees to be paid to Authorities relating to service interruptions.

I.8 The Works related to the relocation of water pipes, stormwater pipes and sewer pipes shall be carried out in accordance with Division 8 of the Specification: Drainage and Water Services and the utility owner and/or service provider's requirements.

I.9 The relocation of water pipes shall not be carried out until the Contractor obtains written approval from the Water Authority. The Contractor shall provide, at his own expense, all bonds and guarantees required by the Water Authority before relocation.

I.10 The Works related to the relocation of electric cables, posts, electric pylons, telephone cables and posts, etc. shall be carried out in accordance with Division 7 of the Specification: Street Lighting and Electrical Works and according to the Utility Owner and/or service provider's requirements. The Contractor shall contact the Utility Owners and/or service provider and prepare the necessary plans for the relocation of these utilities. Relocation works shall be carried under the supervision of the Utility Owner or service provider and completed works shall be subject to their acceptance.

J. Removal of Advertising Signs and Billboards

The removal of advertising signs and billboards located in the ROW shall be carried out by the Contractor in coordination with the concerned Authorities and respective Owners, unless the Owner indicates his intention to carry out such removal. The removed signs and billboards shall be transported and stored at the Owner's premises as directed by the Engineer.

K. Removal of Existing Roadside Furniture

Where necessary for the construction of the Works, or when instructed by the Engineer, the Contractor shall remove all roadside furniture including traffic signs, road studs, vehicular safety barriers, posts and foundations. The furniture shall be transported and stored for reuse or returned to the relevant owner as directed by the Engineer and all holes and voids resulting from the removal shall be infilled and compacted in accordance with these specifications.

L. Removal of Existing Bituminous and Cement Concrete Pavement

Unless otherwise detailed on the Drawings, the Contractor shall have the option to remove, pulverize, crush, blend and process existing bituminous and cement concrete pavement (including sidewalks, curbs, gutters and stairs) which are specified to be removed and use such materials in the new construction. All such salvaged pavement, proposed for use in new construction, shall be processed to conform to all specified gradation and quality requirements for the material to be placed in the new construction.

M. Removal of Existing Railway Tracks

M.1 The Contractor shall liaise with the Railway Authority in connection with removal of railway lines within the ROW. Dismantling of railway tracks and railway structures shall be carried in accordance with the Railway Authority's requirements. The Contractor shall comply with all regulations of the Railway Authority in executing work in or adjacent to their property.

M.2 The railway tracks shall be salvaged. All salvaged materials shall be inventoried, transported and delivered to the Railway Authority's stores as directed by the Engineer.

N. Cleaning of Existing Drainage Structures

Where shown on the Drawings or instructed by the Engineer, existing drainage structures (culverts pipes, ditches and the like) shall be cleared of all silt and debris to the satisfaction of the Engineer. All waste material shall be disposed of off site in accordance with Part 2.02.3 of this Section.

O. Raising or Lowering of Manhole and Road Gully Cover Levels

The Contractor shall raise or lower the levels of existing manhole and gully covers where necessary to suit the adjusted road profile. Care shall be taken in lifting the covers and frames to avoid damage to the metalwork and chamber concrete. The covers and frames shall be reset to the finished road level in accordance with the requirements of Specification Section 8.05: Manholes, Chambers and Gullies. If, in the opinion of the Engineer, the Contractor damages frames or covers through neglect, the Contractor shall provide replacements , to the satisfaction of the Engineer, and at the Contractor's expense.

2.02.4 MEASUREMENT

A. Demolition and removal of existing buildings shall be measured by the square metre of the built surface area demolished including the ground floor slabs. The price shall include, but not be limited to, the following: -

- Demolition and disposal of all kinds of materials in the existing building including any foundations, walls or retaining structures.
- Disposal of materials other than those remaining the property of the Employer or those for reuse.
- Clearing, storing, protecting and transporting materials remaining the property of the Employer or those for reuse.
- Temporary support incidental to the demolition.
- Leaving parts of existing walls temporarily in position to act as buttresses.
- Temporarily redirecting, maintaining or sealing of existing services.
- Backfilling with suitable material and compacting up to ground level holes and voids arising from the demolition works
- Making good sections of buildings not to be demolished including all necessary finishing works.
- Other requirements as described by or in accordance with the Contract Documents and Drawings

B. Demolition and removal of existing structures, including bridges and culverts, shall be measured by the individual item. The price shall include the demolition and disposal of all kinds of materials in the existing structure including any foundations, walls, or retaining structures. The price shall include the following: -

- Demolition and disposal of all kinds of materials in the existing structure including any foundations, walls or retaining structures.
- Disposal of materials other than those remaining the property of the Employer or those for reuse.
- Clearing, storing, protecting and transporting materials remaining the property of the Employer or those for reuse.
- Temporary support incidental to the demolition.
- Leaving parts of existing walls temporarily in position to act as buttresses.
- Temporarily redirecting, maintaining or sealing of existing services.
- Backfilling with suitable material and compacting up to ground level holes and voids arising from the demolition works
- Making good sections of buildings not to be demolished including all necessary finishing works.

- Other requirements as described by or in accordance with the Contract Documents and Drawings.

C. Unless specifically itemised in the Bill of Quantities or instructed by the Engineer, removal of existing pipes shall not be measured separately and the costs of excavation, removal, disposal, repair and backfilling shall be deemed to be included in the Contract prices for other pay items.

D. Removal and disposal of large rocks and boulders shall be measured by the cubic metre of unclassified highway excavation as prescribed in Section 2.03: Highway Excavation.

E. Removal and/or relocation of existing fences and walls shall be measured by the linear metre. The price shall include for, but not be limited to, dismantling of existing fencing, removal of post footings, transportation, storage and repair of existing fencing, backfilling and material compaction of existing post holes and re-erection on the existing fencing; all in accordance with these Specifications.

F. Removal of existing wells shall be measured by the number of wells dismantled, backfilled and compacted. The price shall include for**,** but not be limited to, removal, transportation and storage of salvageable materials, backfilling and compaction; all in accordance with these Specifications.

G. Removal of trees with a girth in excess of one metre shall be measured by the number of trees felled and stumped. The price shall include for, but not be limited to, felling, removal of stumps, transportation and disposal of timber and roots, backfilling and compaction to existing ground level; all in accordance with these Specifications.

H. Removal and Relocation of Utilities

H.1 Permanent realignment or replacement of Utilities shall be measured and paid in accordance with the rates set in the Bill of Quantities for the respective works. Where the Bills of Quantities contain a Provisional Sum for Realignment or Replacement of Utilities, payments shall be made against invoices and receipts for realignment, replacement or permanent diversion works approved by the Engineer and carried out by the Utility or Service Provider, a sub contractor nominated under the Contract or approved by the Engineer or against work directly carried out by the Contractor which has been negotiated and agreed with the Engineer prior to the execution of the work.. This Sum shall only be expended against works which are not accounted for as Pay Items elsewhere in the Specification or the Bill of Quantities.

H.2 The relocation or removal of electric and telephone overhead and underground cables shall be paid by the linear metre of the existing length of the cable. Rates shall include for, but not be limited to, preparation and submittal for the necessary plans for the relocation of these utilities, relocation of utilities, coordination with the Utility Owner and/or Service Provider, all fees required by these authorities for the supervision of the relocation or removal works, excavation, handling, transportation, replacement and repair of damaged cables, backfilling of all excavations, all other necessary installation works and commissioning; all in accordance with these Specifications.

H.3 The relocation or removal of electric, lighting and telephone poles, posts, pylons, shall be paid by the number relocated or removed. Rates shall include for, but not be limited to, preparation and submittal for the necessary plans for the relocation of these utilities, relocation of utilities, coordination with the Utility Owner and/or Service Provider, all fees required by these authorities for the supervision of the relocation works, excavation, dismantling, handling, transportation, replacement and repair, backfilling of all excavations, reassembly, re-erection all other necessary installation works and commissioning; all in accordance with these Specifications.

H.4 Rates for the relocation of potable water, storm water and sewer pipe lines shall be shall be paid by the linear metre of the existing length of the pipelines. The rate for potable water relocation works shall include for, but not be limited to, preparation and submittal for the necessary plans for the relocation of these utilities, relocation of utilities, all related incurred costs, including the costs of coordination with the water authority during the relocation to supervise any works including any fees related thereto, excavation, handling, transportation, replacement and repair of damaged pipes, backfilling of all excavations, all other necessary installation works and commissioning, all in accordance with these Specifications.

H.5 Temporary relocation and diversion of utilities required during construction, irrespective of the number of relocations and diversions required, supporting and protecting realigned and existing utilities that are to remain in place, including, but not limited to, all necessary temporary works shall not be measured for direct payment, but shall be considered as subsidiary works; the costs or which shall be deemed to be included in the Contract prices for Pay Items.

H.6 Survey works, investigation and mapping of existing utilities and obstructions, coordination costs, and fees requested by Utility Owners shall not be measured for direct payment, but shall be considered as subsidiary works the costs of which shall be deemed to be included in the Contract prices for Pay Items.

I. Removal of signs, billboards, poles and road studs shall be measured and paid by the item dismantled, stored, transported and rehabilitated, reused or disposed of off site. The price shall include for, but not be limited to, dismantling, removal and disposal of footings, transportation, storage and repair, backfilling and material compaction of holes and voids and re-erection, delivery to the owner's premises or disposal off site; all in accordance with these Specifications.

J. Demolition of existing barriers shall be paid by the linear metre of barrier to be

demolished. The rates shall include for, but not be limited to, dismantling, removal and disposal of footings, transportation, storage and repair, backfilling and material compaction of holes and voids and re-erection, delivery to the owner's premises or disposal off site; all in accordance with these Specifications.

K. Removal of roadways and existing bituminous and concrete pavements shall be measured by the cubic metre of unclassified highway excavation as prescribed in Section 2.03 - Highway Excavation.

L. Removal of railway tracks shall be measured by the linear meter of track, measured along the centreline of the tracks, for the works specified. The price shall include for, but not be limited to, coordination with the Railway Authority, lifting of the track, loading and transportation to the Railway Authority depot.

M. Adjustment of manhole and gully cover levels shall be measured by the number of covers and frames adjusted as specified and accepted. The price shall include for, but not be limited to, removal and storage of the covers and frames for reuse, adjusting the level of the existing manhole neck and reinstallation of the covers and frames. The rate shall include saw cutting of the existing asphalt layer where applicable, excavation around the manhole (or the like), demolition and reconstruction of the access shaft, removing, cleaning, painting and reinstalling the existing manhole cover and frame (or the like) to the finished grade in either brickwork or concrete as appropriate.

N. Cleaning of existing box culverts, waterways, open concrete side drains and covered concrete side drains shall be measured by the linear metre of the section to be cleaned. The price shall include for, but not be limited to, cleaning and clearing, by mechanical means or by hand, transporting and disposing of silt and debris, above and below the waterline; all to the satisfaction and approval of the Engineer.

SECTION 2.03 SUBGRADE CONSTRUCTION

2.03.1 SCOPE

A. The work covered in this Section consists of furnishing materials, constructing the subgrade layer and preparing the subgrade surface ready to receive the pavement structure and shoulders, all as and where shown on the Drawings.

B. The subgrade layer is the selected material immediately below the subgrade surface.

2.03.2 MATERIALS

A. Subgrade material shall consist of selected material having a 4-day soaked CBR of not less than 20% when tested in accordance with AASHTO T 193 when compacted at 100% of modified proctor AASHTO (T-180-D) and having a maximum P.I. of 12%. Subgrade gradation shall be reasonably smooth without gap grading. All material shall pass the 75 mm sieve and not more than 18% shall pass the 0.075 mm (No. 200) sieve.

B. Minimum tests required on subgrade are listed in Section 2.06 - Embankment Construction

2.03.3 CONSTRUCTION

A. Subgrade in Cut

A.1 Where the subgrade is located in rock, the subgrade, unless shown otherwise on the Drawings, shall be undercut to a depth of 200 mm by drilling or blasting as directed. No rock shall project more than 50 mm above the undercut surface elevation. The subgrade layer shall then be constructed using approved subgrade material, as specified for subgrade in embankment.

A.2 Where the subgrade is on in-situ soil which is of a quality and CBR value at least equal to those specified for subgrade, the 200 mm depth of such material immediately below top of subgrade shall be scarified and all roots, topsoil, vegetable and other undesirable matter and rock particles larger than 75 mm in any dimension shall be removed. The material shall then be brought to a uniform moisture content within the specified range and compacted to 100% AASHTO T 180 (Method D) maximum density.

A.3 Where the subgrade is on in-situ soil which is unsuitable for retention as the subgrade layer, the material immediately below the top of subgrade layer shall be excavated, hauled away and disposed of unless approved for use as embankment fill. The subgrade layer shall then be constructed using approved subgrade material, as specified for subgrade in embankment. If the material below sub-grade does not satisfy the earthworks requirement to a depth of 60 cm, it shall be excavated for further 20 cm and replaced by suitable material.

A.4 The underlying material shall be scarified, levelled and rolled. The prepared surface shall be approved by the Engineer before placement of suitable material.

B. Subgrade in Embankment

The minimum layer thickness of subgrade shall be 20 cm unless otherwise shown on the Drawings or directed by the Engineer. The material in the layer underneath the subgrade shall consist of selected, approved subgrade material. The subgrade material shall be spread in one layer over the full width of the top of embankment, brought to a uniform moisture content within the specified range and compacted to 100% AASHTO T 180 (Method D) maximum density.

C. Surface Tolerances

C.1 All finished elevations, lines and grades shall be in accordance with the details shown on the Drawings. Each cross section shall be checked at maximum intervals of 25 metres, at each change in cross slope and elsewhere as directed by the Engineer.

C.2 The tolerances on elevations of finished subgrade, top of embankment under the subgrade layer and excavated surface in cuts shall be as follows:

Surface	**Tolerances**
Finished Subgrade:	
Soil	+10 or -30 mm
Rock (if approved)	+50 or -50 mm
Top of Embankment or Excavated Cut Surface:	
Soil	+10 or -30mm

C.3 When the finished subgrade surface is tested with a 4 m long straightedge placed parallel to, or at right angles to the centreline, the maximum depression of the surface from the testing by straight edge shall be 30 mm.

D. Maintenance of Finished Subgrade

The completed approved subgrade shall be continuously maintained in a smooth, well compacted and properly drained condition until the overlying sub-base (or base) course is constructed. The Engineer shall inspect and approve the condition of the subgrade immediately prior to the placement of the overlying layer.

2.03.4 MEASUREMENT

A. Subgrade layer preparation in embankment shall not be measured separately but shall be deemed to be included as part of embankment construction.

B. Subgrade preparation in cut including all excavation below top of subgrade, scarifying, removing undesirable matter and compacting shall be deemed payable as unclassified highway excavation.

SECTION 2.04 STRUCTURAL EXCAVATION AND BACKFILL

2.04.1 SCOPE

A. The work covered in this section consists of all excavation in any material for bridges, underpasses, overpasses, buildings, pump houses, box culverts, utility ducts, underdrains, drainage and utility structures, retaining walls of all types and for other major and minor structures; and including all necessary clearing and grubbing; bailing; drainage; pumping; sheeting; temporary shoring and cribbing, construction of temporary cofferdams or cribs, disposal of all excavated material and backfilling with suitable approved material, all as and where shown on the Drawings. This section does not include excavation and filling for drainage, sewage and water pipe trenches.

B. The work covered also includes the removal of sections of existing structures below ground which obstruct or interfere with the construction of new structures.

C. The Contractor shall have deemed to have satisfied himself, at the time of tendering, as to the type and nature of soils and rock that will be encountered in structural excavations.

2.04.2 EXCAVATION

A. General

A.1 The Contractor shall notify the Engineer in advance of the beginning of any excavation for structures so that the Engineer may, where necessary, survey and record the cross sectional elevations and measurements of the existing ground and existing structures affected by the proposed construction. Any materials removed or excavated before these measurements have been taken and approved by the Engineer shall not be paid for.

A.2 The Contractor shall be solely responsible for the safety at all times of all foundation and trench excavations whether supported or otherwise. Approval of the Contractor's support system or omission of a support system for any excavation shall not absolve the Contractor from his sole responsibility in this regard.

A.3 The Contractor shall take all necessary precautions, including shoring or otherwise, to protect employees in the excavation and on the ground above. The Engineer shall not enter excavated areas to approve the foundation and further work until he deems the areas to be safe.

A.4 In areas where the excavation is adjacent to public roads and walkways, the Contractor shall erect all necessary barricades, barriers, enclosed walkways, and warning signs necessary to restrict the exposure of the public to the excavation. All such safety measures shall conform to the requirements of Section 6.07 - Maintenance of Traffic and Detours and shall be subject to the approval of the Engineer.

A.5 The sides of all foundation pits and trenches shallower than 1.2 metres shall be vertical and adequately supported at all times to the satisfaction of the Engineer. Sides more than 1.5 m in depth shall be either sloped or supported. The Contractor shall demonstrate the stability of the slope gradient or the support system to the Engineer prior to and during excavation and entry.

A.6 Pits and trenches shall be kept free from water until footing concrete has been placed or drainage has been installed. The Contractor shall minimize, to the maximum extent practicable, the length of time excavated areas are left open. The Contractor shall be held responsible for damage due to weather, equipment and other causes during periods when the excavations are left open.

A.7 The Contractor shall schedule the his work in order that no excavation is left in an exposed condition for a period greater than 30 days unless otherwise approved by the Engineer.

A.8 In areas where the excavation is adjacent to public highways and walkways, no excavation shall be left open for more than 7 days unless otherwise approved by the Engineer.

A.9 The Contractor shall schedule highway excavation and embankment and drainage works to complement each other. If the Contractor's earthwork progress exceeds the progress of the drainage construction to the point where the highway obstructs water flow, the Engineer shall instruct the Contractor to open adequate waterways through the highway at the locations where drainage structures are to be installed. Any damage to the highway caused by water passing through these openings shall be repaired at the Contractor's expense.

A.10 The Contractor shall notify the Engineer of any sign of failure or cracks within or around the excavation immediately when noticed.

A.11 Exploratory trench excavation 1m deep and 2m wide shall be carried out across structure footings and pile caps, either manually or using light equipment, under the close supervision of the Engineer to check the existence of archaeological remains, prior to commencement of full scale structure excavation.

B. Temporary Support System

B.1 Temporary support systems shall be used to protect the public and adjacent property during construction as necessary. The Contractor's design for such support system shall be submitted the Engineer for approval prior to commencing its construction.

B.2 All temporary support systems shall be designed with adequate factors of safety and with minimal maintenance requirements for the duration of their intended use and shall include adequate safety provisions to protect the public from construction activities.

B.3 Notwithstanding any approval of temporary support systems, the Contractor shall be solely responsible for the adequacy of their design and construction and for maintenance and all necessary safety precautions associated therewith.

C. Excavation for Bridges, Underpasses, Overpasses and other Major Structures

C.1 The foundations for bridges, underpasses, overpasses, buildings, pump houses and other major structures shall be excavated in accordance with the dimensions shown on the Drawings and shall be of sufficient size to permit the placing of the full widths and lengths of the footings.

C.2 The excavation shall be carried to the elevations shown on the Drawings or as established by the Engineer. Borehole records and results from soil tests undertaken during design and actual investigation of the completed foundation excavation shall be utilized by the Engineer to confirm the final depth. No concrete shall be placed in the excavation prior to the approval of the Engineer.

C.3 Unless shown otherwise on the Drawings, the base of all excavations shall be covered with a 100 mm minimum depth of lean (blinding) concrete Class 110/25 to serve as a working platform.

C.4 Foundation pits or trenches shall be of sufficient size and provide minimum sufficient working space to permit construction of structures or structure footings of the full width and length shown on the Drawings.

C.5 Where footings are to be constructed using formwork, the excavations shall not extend more than 500 mm beyond the maximum dimension on each side of the proposed footing unless additional working space is clearly required and approved by the Engineer. Any unauthorised overwidth of excavation beyond the lateral limits shown on the Drawings or approved by the Engineer shall be backfilled with selected fill or lean concrete as directed by the Engineer.

C.6 Where footings are to be located in or adjacent to firm original ground and where formwork is not required or ordered, any unauthorized overdepth excavation below the approved elevation of base of footing shall be backfilled with blinding concrete.

C.7 Where excavation to rock foundation is required, the excavation shall proceed to allow the solid rock to be exposed and prepared in horizontal beds or properly serrated for receiving the blinding concrete. All loose and disintegrated rock and thin strata shall be removed.

C.8 All blasting necessary for any pier or groups of piers or abutment shall be performed prior to placing any concrete. Blasting shall not be permitted in the vicinity of concrete which has not cured for at least 14 days. Blasting shall not affect concrete properties and integrity.

C.9 When, in the opinion of the Engineer, unsuitable material including garbage and domestic waste is encountered below foundation elevation, the Contractor shall excavate such material and replace it with suitable backfill material or concrete as shown on the Drawings or directed by the Engineer.

C.10 The Contractor shall be responsible for the design and execution of the temporary drainage works for all excavations. The Contractor's proposals shall be submitted to the Engineer for approval. Such approval does not relieve the Contractor for his sole responsibility in this regard.

D. Excavation for Box Culverts, Ducts and Miscellaneous Structures

D.1 Excavation shall be carried out to the limits required for construction and to the depth required for bedding material or for removal of unsuitable material. All trench excavation shall proceed upgrade, commencing at the downstream end.

D.2 Foundation material supporting the bedding or structure shall be AASHTO M 145 Class A-1-a, A-1-b or A-2-4 material compacted to 95% AASHTO T 80 maximum density. If natural material does not meet the classification requirements, it shall be subexcavated to a depth of at least 200 mm and replaced with material meeting the specified requirements. Any rock or hard material within 200 mm of the bottom of the pipes shall be similarly subexcavated and replaced with material meeting the specified requirements.

D.3 If special bedding material is not required, the foundations for precast and prefabricated culverts shall be formed to the shape of the culvert, including all protrusions. The shaping shall extend to 25% of the height of culvert.

D.4 The Engineer shall determine where rock encountered in the toe wall excavations for concrete box culverts, concrete headwalls or endwalls for pipe culverts is sufficiently competent to form part of the structure foundations.

D.5 When excavation is required for installation of ducts, the Contractor shall notify the Engineer upon completion of the excavation. No duct shall be laid until the depth and cross section of the excavation has been approved by the Engineer.

2.04.3 BACKFILLING

A. General

A.1 The Contractor shall obtain the Engineer's approval for his proposed method and rate of placing of backfill, before backfilling commences.

A.2 Backfill materials shall be uniformly graded granular material, capable of meeting the specified compaction requirements and having adequate permeability to permit free drainage through it. Backfill material shall conform to the following and to the values specified in subsequent sections:

- Minimum D10 value: 1 mm
- Maximum Plasticity Index: 10 per cent

A.3 Backfill under foundations shall not contain material with more than 10% fines passing the No. 200 sieve.

A.4 Backfill material shall not be placed against any structure until approval by the Engineer has been given. Unless otherwise shown on the Drawings, structures shall be backfilled to the same requirements as specified for the adjacent embankment.

A.5 Backfill shall be placed in level layers to the full width of the excavated area until the elevation of the original ground or surrounding embankment is reached. Backfill next to walls, between columns or in other confined areas, shall be compacted by hand methods or portable equipment as approved by the Engineer.

A.6 Each successive layer of backfill shall contain only sufficient material to ensure proper compaction and no layer shall be greater than 250 mm thick before compaction. The moisture content of the backfill material shall be uniform and within the designated range.

A.7 Jetting of fills or other hydraulic methods involving or likely to involve liquid or semi-liquid pressure shall not be permitted.

A.8 Water shall be drained from the areas to be backfilled wherever practicable. In cases where, in the opinion of the Engineer, it is not practicable to drain the areas to be backfilled, the initial backfill material shall consist of crushed, open graded material conforming to the following gradation:

ASTM Sieve Size	**Percentage Passing**
10mm (3/8")	100
No. 4	< 85
No. 30	< 45
No. 200	< 5

Such material shall be deposited without compaction only below the standing water level. Above the water level normal laying and compaction methods shall be employed.

A.9 Additional water added during placement of backfill material to achieve the required compaction shall be fresh water unless otherwise approved by the Engineer.

A.10 The minimum tests required for verification of fill material in each separate structural excavation are as follows: -

- One Proctor test
- One Gradation of Materials for each materials source or variation of material
- One Plasticity Index and field density for each compacted layer.

The Contractor shall carry out additional testing at no additional cost to the Contract if so instructed by the Engineer.

B. Backfilling for Bridges, Underpasses and Overpasses

B.1 Structures shall not be subject to the pressures of backfilling or to live loads until the 28-day strength of the concrete has been reached, unless a shorter period is approved in special circumstances where the load is sufficiently small as not to constitute a risk of any damage to the structure in the opinion of the Engineer. This period shall be extended if subnormal curing conditions exist.

B.2 Backfill placed around culverts, abutments and piers shall be deposited on all sides to approximately the same elevation at the same time. Special care shall be taken to prevent any wedging action against the structure and slopes adjacent to the excavation shall be stepped, as necessary, to prevent such wedge action occurring.

B.3 All backfill intended to support falsework loads, including temporary fills and pier backfill, shall be designed for the minimum support required. As a minimum, such material shall be AASHTO M 145, Class A-1-a, A-1-b or A-2-4, compacted to 90% AASHTO T 180 maximum density.

B.4 Backfill material for bridge abutments and approach embankments within 20 metres of any part of the substructure shall be AASHTO M 145, Class A-1-a, A-1-b or A-2-4 compacted to 95% AASHTO T 180 maximum density up to the underside of the subgrade layer. The 200 mm minimum thickness of subgrade layer shall consist of approved subgrade material placed and compacted to 100% maximum density as specified under Section 2.07: Subgrade Construction. The backfill shall be completed to the level of the original ground or to the top elevation of any adjacent embankment.

B.5 Backfill around retaining walls shall be completed to the level of the original ground line and to such heights above original ground line or to the levels as shown on the Drawings. Care shall be exercised to prevent forward movement of the wall.

B.6 Unless shown otherwise on the Drawings, where special permeable backfill (sheathing) is to be placed against the back faces of abutments, retaining walls or wing walls, it shall consist of a continuous covering of proprietary filter cloth protected by a continuous wall of 200 mm minimum thickness precast porous (no-fines) concrete blocks laid in stretcher bond with dry joints. Prior to construction of the block wall, a Type 1 or Type 3 underdrain of at least 150 mm diameter shall be laid along the base of the wall under the sheathing in accordance with the relevant requirements of Section 6.04: Pipe Underdrains.

C. Backfilling for Box Culverts and Miscellaneous Structures

C.1 Backfill material for box culverts and miscellaneous structures within 300 mm of any part of the structure shall be Class A-1-a, A-1-b or A-2-4. Backfilling and construction of the subgrade layer shall be as specified for bridges, underpasses and overpasses.

C.2 Backfill around and over pipe culverts shall not commence until headwalls and wingwalls have been constructed and attained the specified 28-day strength.

C.3 Water used for compaction of backfill around metal pipes shall be from a source approved by the Engineer and shall not contain more than 0.5% combined chlorides and sulphates nor contain other potentially harmful minerals.

C.4 When pipes or other structures temporarily extend above the grade of the partially constructed embankment, the Contractor shall construct the fill over the structure of sufficient depth to protect the structure from any damage resulting from construction or other traffic.

C.5 Surplus material shall not be dumped in stream channels.

C.6 The Contractor shall complete the backfill around box culverts to the level of the original ground line and to the full width of excavation area. If the top of culvert extends above the original ground line the Contractor shall continue the backfill to the top of the culvert and for a width of 3 m on each side of the culvert for the full width of highway embankment. If the embankment is in place at the time of backfilling, the Contractor shall backfill around the culvert to the top of embankment.

C.7 Backfill around pipe culverts and storm drains shall be completed to the level of original ground line and to the full width of excavation area. If the top of the culvert extends above the original ground line the Contractor shall continue the backfill to the top of culvert for a width of 1.5 times the maximum external width of the culvert on each side of the culvert centreline to the full width of the highway embankment. If the embankment is in place at the time of backfilling, the Contractor shall backfill around the culvert to the top of culvert or as shown on the Drawings.

C.8 Any existing highway pavement cut through, damaged or removed during excavation for pipe culvert installation shall be reinstated after pipe installation and trench backfilling using base and surface course materials at least equivalent to those in the original pavement. Materials and construction shall conform to the relevant requirements of Section 4.08: Pavement Repairs and Trench Reinstatement Works.

C.9 Miscellaneous structures other than pipe culverts and storm drains shall be backfilled in accordance with the methods specified on the drawings or instructed by the Engineer. Compaction of backfill of structures outside the highway right-of-way or in approach roads, minor roads or similar areas shall be to 90% AASHTO T 180 maximum density.

D. Permeable Drainage Layer to Abutments, Retaining Walls and Bases of Structures

The drainage layer shall consist of clean single size no-fines gravel having a minimum size of 20 mm and minimum thickness of 300 mm.

2.04.4 MEASUREMENT

A. Structural backfilling, except permeable backing behind abutments and walls and for reinforced earthwalls, shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Structural Excavation.

B. All structural excavation of whatever type shall be measured as "unclassified" which shall be deemed to include all materials encountered of any nature, including silts, clays, sand, gravel and granular materials and fractured, jointed and solid rock.

C. Structural excavation for box culverts less than one square metre in external cross section and structural excavation for ducts, underdrains (subsoil drains), pits, slope protection works, fence posts, guardrail posts, lighting columns, sign posts, signal supports and all other minor structures, shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract Prices for Pay Items.

D. Structural Excavation shall be measured by the cubic metre of material excavated hauled away and disposed of as directed, or stockpiled on or in the vicinity of the Works and the excavated areas backfilled, completed and accepted.

E. Measurement of structural excavation shall be of original ground elevations or ground elevations after removal of all unclassified highway excavation. Limits shall not be greater than vertical planes 500 mm from the maximum dimension, on each side of the footing or other controlling portion of the structure. Where structures are to be constructed against natural ground or rock, excavation limits shall be the dimensions of the structure as shown on the Drawings. Bottom limits shall be the ordered foundation elevations. Only material excavated from its original position shall be measured for payment. No measurements shall be made of structural excavation in embankments previously constructed by the Contractor.

F. Additional excavation in unstable material or other unsuitable material including garbage and domestic waste encountered below foundation level shall be measured as unclassified structural excavation.

G. Unauthorized overdepth and overwidth excavation in soil and rock and the backfill material including blinding concrete shall not be measured for direct payment, but shall be considered as subsidiary works the costs of which will be deemed to be included in the Concrete Prices for Pay Items.

H. Temporary cofferdams, temporary support system, bailing, drainage, pumping, sheeting, and all other temporary works shall not be measured for direct payment, but shall be considered as subsidiary works the costs of which will be deemed to be included in the Contract Prices for Pay Items.

I. Permeable drainage layer (permeable backing) shall be measured by the cubic metre, placed and accepted.

J. Fill behind reinforced soil and anchored earth walls shall be measured by the cubic metre, placed compacted and accepted.

SECTION 2.05: EARTHWORK OF WET INFRASTRUCTURE SYSTEMS

2.10.1 SCOPE

The work covered in this section consists of all excavation, filling and backfilling, stockpiling for wet infrastructure systems.

2.05.2 GENERAL

A. The Contractor shall carry out all the necessary excavations for trenches and structures such as manholes, inspection chambers, etc. for potable water, storm water, and sewerage (waste water) pipelines and network, to the required lines and grades and in any types of soil and ground of whatever nature may be. He shall backfill and compact such excavations in layers and to the extent specified and shall dispose of unsuitable and surplus material to approved dumping areas.

B. The Contractor shall furnish and place all sheeting, bracing and supports, execute all cofferdaming, pumping and draining and shall render the bottom of the excavations firm and dry until acceptable in all respects.

C. Excavations shall be carried out to the dimensions shown in the drawings and in such a manner to provide suitable room for building the structures or laying and joining the pipework.

D. All excavations, except as otherwise specified or permitted shall be made in the open and shall be carried out in such portions at one time as the Engineer may direct, in order to avoid inconvenience to the public and maintain safety of operations.

E. Excavation, dewatering, sheeting and bracing shall be carried out in such manner as to eliminate all possibility of undermining or disturbing existing services, foundations of existing structures or of work previously executed under this Contract.

F. The Contractor is to visit the Site, satisfy himself as to the nature of the ground and sub-soil to be excavated and make himself conversant with the local conditions to be encountered during the execution of the Contract. Any claims arising from want of knowledge in this respect shall not be entertained.

2.05.3 STANDARDS AND CODES

The following standards and codes in their latest edition shall be particularly applied to works covered by this section.

ASTM

C 88 Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
C 117 Test Method for Material Finer than 0.075mm (No. 200) Sieve in Mineral Aggregates by Washing

C 131 Tests Method for Resistance to Degradation of Small-Size Coarse Aggregates by Abrasion and Impact in the Los Angeles Machine
C 136 Method for Sieve Analysis of Fine and Coarse Aggregates
D 75 Practices for Sampling Aggregates

D 345 Sampling and Testing Calcium Chloride for Roads and Structural Applications
D 421 Practice for Dry Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants
D 422 Particle Size Analysis of Soils
D 854 Specific Gravity of Soils
D 1556 Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
D 1883 Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils
D 2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
D 2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregates
D 2937 Test Method for Density and Unit Weight of Soil in Place by the Drive-Cylinder Method
D 2974 Standard Method of Test for Moisture, Ash and Organic Matter of Peat and Other Organic Materials
D 2976 Standard Method of Test for pH of Peat Materials
D 2977 Standard Method of Test for Partical Size Range of Peat Materials for Horticultural Purposes
D 3282 Classification of Soils and Soil-Aggregate Mixtures for highway Construction Purposes
D 4318 Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils
D 4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method

AASHTO

M 145 Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
T 2 Sampling Aggregates
T 11 Amount of Material Finer than 0.075mm Sieve in Aggregate
T 27 Sieve Analysis of Fine and Coarse Aggregates
T 86 Investigating and Sampling Soils and Rock for Engineering Purposes
T 87 Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
T 88 Particle Size Analysis of Soils
T 89 Determining the Liquid Limit of Soils
T 90 Determining the Plastic Limit and Plasticity Index of Soils
T 93 Determining the Field Moisture Equivalent of Soils
T 96 Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
T 100 Specific Gravity of Soils
T 104 Soundness of Aggregate by Use of Sodium or Magnesium Sulphate
T 143 Sampling and Testing Calcium Chloride for Roads and Structural Applications
T 176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
T 180 Moisture-Density Relations of Soils using a 10 lb (4.54 kg) Hammer and an 18 in (457mm) Drop
T 191 Density of Soil In-Place by the Sand-Cone Method
T 193 The California Bearing Ratio
T 204 Density of Soil In-Place by the Drive Cylinder Method
T 205 Density of Soil In-Place by the Rubber-Balloon Method
T 217 Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester.

BS

BS 5930 Code of Practice for Site Investigations

2.05.4 EXCAVATION IN RESTRICTED AREA

In conformity with the Drawings, or as necessitated by Site conditions, or directed by the Engineer, the Contractor shall carry out excavations in restricted areas close to existing structures and utilities by hand in order to safeguard such structures and utilities from any damage whatsoever. The Contractor shall make good at his own cost any damage caused by him to these existing structures and utilities.

2.05.5 METHODS OF DETECTION OF EXISTING UTILITIES

A. Use of Metal Detector

Prior to the start of excavating any trial pit, the Contractor shall check using a METAL DETECTOR or other equipments the presence of existing utilities.

B. Trial Excavation

B.1 Prior to any excavation, the Contractor shall carry out trial trench and pit excavations to such extent as required in order to locate and expose existing buried services and utilities, or reveal ground conditions etc,. The Contractor shall submit for approval a drawing showing the proposed location of all trial excavations to the Engineer. The prior approval of the Engineer shall be obtained for such excavations.

B.2 Unless otherwise approved, trial excavations shall be carried out by hand and in a manner to ensure that damage to existing utilities are avoided.

B.3 The Contractor shall submit to the Engineer for his approval a written report and drawings of the data obtained from trial excavations carried out at every location. No backfilling of such excavations shall be made prior to the approval of the Engineer. The Contractor shall reinstate and make good these trial pits.

2.05.6 SHEETING AND BRACING

A. The Contractor shall furnish, put in place and maintain such sheeting, bracing, shoring etc. as may be necessary to support the sides of the excavation and to prevent any movement of earth which could in any way diminish the width of the excavation to less than that necessary for proper construction, or could otherwise injure or delay the work, or endanger work people, adjacent services or structures. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports to be put in at the expense of the Contractor.

B. In addition, wherever the excavations for trenches or structures are under water or are greater than three (3) meters below ground level, the Contractor shall present to the Engineer, for his approval, construction drawings indicating the proposed method of excavating, dewatering, supporting the sides of excavation such as trench sheeting and shoring, sheet piling etc. and all other pertinent details relating to pipe laying and/or construction of structures.

C. Wherever possible, sheeting shall be driven ahead of the excavation to avoid loss of material from behind the sheeting. If it is necessary to excavate below the sheeting, care shall be taken to avoid trimming behind the face along which the sheeting will be driven. Care shall be taken to prevent voids outside of the sheeting, but, if voids occur, they shall be filled immediately with sand and compacted.

D. The Contractor shall leave in place to be embedded in the backfill, or concrete, all sheeting, bracing, etc., which is indicated in the Drawings to be so left in place or as may be ordered by the Engineer. He also shall leave in place any and all other sheeting, bracing, etc., which the Engineer may direct him in writing to leave in place, at any time during the progress of the work, for the purpose of preventing injury to structures or property.

E. All sheeting and bracing not to be left in place shall be carefully removed in such manner as not to endanger the construction or other structures. All voids left or caused by the withdrawal of sheeting shall be backfilled immediately with approved material and compacted to the density specified herewith.

2.05.7 STOCKPILING OF EXCAVATED MATERIALS

A. The stockpiling of excavated material on roadways or in any other areas that may cause nuisance to persons or property will not be permitted. If suitable storage areas to the approval of the Engineer are not available adjacent to work areas the Contractor must immediately load and transport all suitable excavated material to be used for select backfill to an approved off-site storage area to avoid any nuisance to persons or property. Surplus or unsuitable excavated material shall be immediately disposed off at an approved disposal location at any distance from the job site. The Contractor shall transport suitable material back to site for backfilling of trenches as soon as backfilling operations starts. The Contractor shall allow for this double handling in his unit rates. The Contractor is responsible for obtaining authorizations for the temporary use of off-site storage locations for excavated material.

B. Excavated select material shall be stockpiled in approved storage areas to avoid obstructing entrances, sidewalks, driveways, hydrants, manholes and any other service and in a manner not to cause any obstruction to traffic. The Contractor shall ensure that stockpiled excavated material does not obstruct pedestrian or driver visibility at road crossings or junctions.

C. Any damage resulting from Contractor's failure to comply shall be rectified at the Contractor's own expense, all as directed by the Engineer.

2.05.8 EXCAVATION IN POOR SOIL

A. The Contractor shall report in writing to the Engineer any unsuitable or weak ground material which may be found below the indicated excavation levels before executing any trimming of the excavation, pipe laying, concreting, or other work.

B. Where the bottom of the trench or structure excavation at subgrade is found to be unstable or to include ashes, cinders, any type of refuse, vegetable or other organic material, stones, or large pieces and fragments of material that, in judgment of the Engineer, should be removed, the Contractor shall excavate and remove such unsuitable material to the width and depth ordered by the Engineer. The over excavation shall be made up by backfilling with suitable material, to the approval of

the Engineer, in layers not exceeding 250 mm loose thickness. The layers shall be placed in accordance with AASHTO T 180 to 95 % compaction to provide a uniform and continuous bearing and support for the pipe. The trench bottom or structure subgrade shall be compacted prior to pipe laying or construction of foundations.

C. All groups of soil classified in accordance with ASTM (D 2487 / D 2488) types CL, OL, MH, CH, OH and PT shall be deemed unsuitable material.

Soil Classification To ASTM D 2487	
Soil Group Symbol	Soil Group Name
CL	Lean Clay
	Lean Clay with sand
	Lean Clay with gravel
	Sandy Lean Clay
	Sandy Lean Clay with gravel
	Gravelly Lean Clay
	Gravelly Lean Clay with sand
OL / OH	Organic soil
	Organic soil with sand
	Organic soil with gravel
	Sandy organic soil
	Sandy organic soil with gravel
	Gravelly organic soil
	Gravelly organic soil with sand
MH	Elastic silt
	Elastic silt with sand
	Elastic silt with gravel
	Sandy elastic silt
	Sandy elastic silt with gravel
	Gravelly elastic silt
	Gravelly elastic silt with sand
CH	Fat clay
	Fat clay with sand
	Fat clay with gravel
	Sandy fat clay
	Sandy fat clay with gravel
	Gravelly fat clay
	Gravelly fat clay with sand
PT	Peat (a soil composed primarily of vegetable tissue in various stages of decomposition, usually with an organic odor, a dark brown to black color, and a spongy consistency.

2.05.9 KEEPING EXCAVATIONS FREE FROM WATER

A. General

A.1 To ensure proper conditions at all times during construction, the Contractor shall provide and maintain ample means and devices (including spare units kept ready for immediate use in case of breakdowns) with which to intercept and/or

remove promptly and dispose properly of all water entering trenches and other excavations. Such excavations shall be kept dry until the structures, pipes and appurtenances are built, backfilling completed, and Engineer's written approval to stop the dewatering of the considered section is granted.

A.2 All water pumped or drained from the work shall be disposed of in a suitable manner without undue interference with other work, damage to pavements, other surfaces, or property. Suitable temporary pipes, flumes, or channels shall be provided for water that may flow along or across the site of the work.

B. Temporary Subdrains

B.1 Temporary subdrains, if used, shall be laid in trenches, beneath the grade of the structure. Trenches shall be of suitable dimensions to provide room for the chosen size of subdrain and its surrounding gravel.

B.2 Subdrain pipe shall be acceptable vitrified-clay, PVC, or concrete pipe of standard thickness. Sewer pipe of the quality known as "seconds" will be acceptable.

B.3 Subdrains, if used, shall be laid at an approved distance below the bottom of the normal excavation and with open joints wrapped in cheesecloth and entirely surrounded by graded gravel, or crushed stone to prevent the admission of sand or other soil into the subdrains. The distance between the bottom of the pipe or structure and the top of the bell of the subdrain pipe shall be at least 8 cm unless otherwise permitted. The space between the subdrain and the pipe or structure shall be filled with screened gravel or crushed stone which shall be rammed if necessary and left with a surface suitable for laying the pipe or building the structures.

B.4 Unless otherwise directed by the Engineer all temporary drains and subdrains shall be finally sealed with concrete at intervals to the Engineer's satisfaction and all temporary ditches, sumps, wells, etc., shall be refilled, all surfaces reinstated and all damage made good as specified or directed.

C. Dewatering System

C.1 The Contractor shall provide, operate and maintain satisfactory an adequate system of pumps, well points, wells, sumps, pipework, drains, intercepting ditches, cut-off drains, subdrains, other dewatering equipment and all other things necessary to keep surface water out of the excavations and to remove from excavations surface water, sub-soil water or water from any other sources and to maintain the water table below bottoms of excavation in order that the construction can be carried out in the dry.

C.2 Prior to dewatering operations, the Contractor shall submit to the Engineer for review detailed procedures and means intended for such dewatering operations.

D. Flooding

The Contractor shall take all precautions, to any extent necessary, to avoid flooding of the excavations either as a result of failure of the dewatering system or of marine flooding, in order to ensure that excavation and backfilling, pipework, structures and appurtenances are constructed and completed to such extent, that such will not be damaged, floated, or subjected to uplift forces which may endanger or in any way

affect their safety. Any damage arising from such flooding shall be made good at the Contractor's expense.

2.10.10 EXCAVATION IN ROCK

A. General

A.1 Rock excavation shall include but not be limited to, all volcanic, alluvial and residual boulders having a volume of 0.50 cubic meters or more, or any other unaltered and unweathered firm and rigid igneous, metamorphic and sedimentary rocks or cemented conglomerates which cannot be removed by normal excavator's tools and equipment and which require drilling, blasting, wedging, sledging, barring or breaking up with power operated tools or other special means for their removal. Isolated boulders or fractured rock that can be removed in pieces not larger than $0.5m^3$ shall not be classified as rock. Where a continuous layer of hard material occurs, it shall not be considered as rock where the thickness of the layers less than 150mm.

A.2 All encountered changes in the type of soil strata, during excavation works, shall be immediately logged and reported to the Engineer's representative for confirmation on site and approval. Unless stated otherwise, such logging shall be incorporated in the measurement of percentages and quantities of rock out of excavated soil as extra over other soil excavations.

A.3 In some circumstances and whenever the Engineer decides it is suitable, a Compressive Strength Tests shall be performed on a certain soil material at the contractor's expenses in order to determine whether excavated materials are to be considered as rock or not.

A.4 Under all circumstances, materials with a compressive strength of $60kg/cm^2$ tested on a 24 hour soaked rock core to ASTM D2938 (or similar approved standard) shall not be counted as rock.

A.5 Rock, boulders, stones, etc., shall be removed to provide a clearance of at least 15 cm. below and to the sides of all pipes, valves, fittings, etc,

A.6 Where pipelines pass from rock to softer strata, the trench shall be excavated to an extra depth of 50 cm. where the rock ends and this extra depth shall be reduced successively in a straight line along a leveling stretch of about three (3) meters to the depth stated above and then backfilled with approved compacted material to the prescribed levels.

B. Rock Blasting

B.1 Rock blasting shall not be carried out without the prior approval of the Engineer. Should such approval be obtained the Contractor will be responsible for obtaining all necessary permits and approvals from the relevant authorities. The Contractor shall take all necessary precautions and measures for re-directing traffic as necessary during blasting operations and shall secure approval of his schedule for such interruptions and his proposed methods for safeguarding the public, property, vehicles and the like in the vicinity of the blasting operations. Where necessary or directed by the Engineer, the Contractor shall provide heavy mesh blasting mats for the protection of persons, properties and the works. If, in the opinion of the Authorities or the Engineer, blasting would be dangerous to persons or adjacent

structures, or is being carried out in a dangerous or unacceptable manner, the Engineer may prohibit blasting and instruct the Contractor to excavate the rock by other means. The Contractor shall bear full responsibility for any damage and injury to persons, properties, utilities and the like as a result of blasting operations.

B.2 When blasting of rock is carried out, a reasonably uniform face shall be left, regardless of whether or not the excavation is carried out beyond the specified limits shown on the drawings. All breakages, slides and debris shall be removed by the Contractor and disposed off as directed.

B.3 All drilling and blasting shall be done in such a manner as will most nearly complete the excavation to the required grade lines and produce the least practicable disturbance of the material to be left in place. Blasting by means of drill holes, tunnels, or any other methods shall be entirely at the Contractor's risk.

B.4 Excessive blasting will not be permitted. Overbreakage and the backfilling thereof shall be at the Contractor's expense. Any material outside the approved cross section limits which may be shattered or loosened because of blasting shall be removed by the Contractor at his own expense. All rock slopes with loose material shall be scaled by workmen and all loose material removed.

B.5 Following blasting, clearing and scaling rock slopes, the face, benches and back of the slope shall be inspected for potential failure planes and the necessary remedial measures shall be taken, as approved by the Engineer.

2.05.11 EXCAVATION FOR TRENCHES

A. General

A.1 The Contractor shall erect all forms and bracing and make ready all excavations for trenches necessary to install all pipelines and any other conduits that may be required for this Contract, to the lines and grades shown in the Drawings and/or as directed by the Engineer.

A.2 Where pipe is to be embedded in sand, gravel or concrete, the trench may be excavated by machinery to, or to just below the designated grade, provided that the material remaining at the bottom of the trench is not disturbed.

A.3 Where pipe is to be laid directly on trench bottom, the excavation by machinery shall be stopped just above the designated grade and the bottom of trenches in earth shall be cut, trimmed and finished by means of hand tools to form a flat or shaped bottom, true to grade, so that the pipe will have a uniform continuous bearing on firm and undisturbed material between joints. If rock is encountered at the designated subgrade, the Contractor shall carry out excavations depending on the pipe diameter, fifteen (15) cm to twenty-five (25) cm below such subgrade and backfilled with approved sand fill or other specified material and compacted in accordance with these specifications.

A.4 During excavation, material suitable for backfilling shall be piled at sufficient distance from the sides of the trench to avoid overloading and prevent cave in or shall be transported to a temporary stockpile away from the site of the works subject to the approval of the Engineer. All excavated material not required, or unsuitable for backfilling, shall be removed and carted away to an approved dumping area.

A.5 Grading shall be done as necessary to prevent surface water or rainwater from flowing into trenches and any water which may accumulate therein shall be removed immediately. Trenches shall be kept dry during the whole period until backfilling is completed and approved.

B. Depth of Trench

B.1 Trenches shall be excavated to such depths as will permit the pipe to be laid at the elevations, slopes, or depths of cover indicated on the drawings and at uniform slopes between indicated elevations.

B.2 The depth of any trench shall be taken to mean the depth from the natural ground surface or reduced level following excavation for other work, whichever is the lowest, to the invert of the pipe, where correctly laid.

B.3 Where rock excavation is encountered, the trench shall be excavated to such extra depth as specified.

C. Width of Trench

C.1 Width of Trench for Sewerage and Stormwater Networks

Pipe trenches shall be made as narrow as practicable and shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches firm and undisturbed until backfilling has been completed and consolidated.

Trenches shall be excavated with approximately vertical sides between the elevation of the center of the pipe and an elevation 30 cm above the top of the pipe. At this elevation the maximum width of trench for single pipes of the various diameters shall be as follows:

SINGLE PIPE TRENCHES FOR SEWERAGE AND STORMWATER NETWORKS

Pipe Diameter (mm)	**Maximum Trench Width @ 30 cm from Top of Pipe, (mm)**
150	650
200	700
250	750
300	800
350	850
400	900
500	1000
600	1600
700	1700
800	1800
900	1900
1000	2200
1100	2300
1200	2400

Pipe Diameter (mm)	Maximum Trench Width @ 30 cm from Top of Pipe, (mm)
1300	2500
1400	2600
1500	2700

C.2 Width of Trench for Potable Water Network

The width of excavation of pipe trenches for potable water networks shall be the minimum required width for efficient working after allowance has been made for any timbering and strutting.

Trenches shall be excavated with approximately vertical sides between the elevation of the center of the pipe and an elevation 30 cm above the top of the pipe. At this elevation the maximum width of trench for single pipes of the various diameters shall be, unless stated otherwise, as follows:

SINGLE PIPE TRENCHES FOR POTABLE WATER NETWORK

Pipe Diameter (mm)	Minimum Trench Width for Rigid Pipes (Ductile Iron, Galvanized Steel as applicable) (mm)	Minimum Trench Width for Flexible Pipes (PE) (mm)
Up to 50 mm	(Galvanized) 500	-------
60 to 100 mm	-------	D + 500
150 to 450 mm	(Ductile Iron) D + 500	-------
500 to 600 mm	(Ductile Iron) D + 1000	-------

C.3 General for Sewerage, Stormwater and Potable Water Networks

For each additional pipe in the same trench, the external diameter of the additional pipe shall be added together with 15 cm to form the minimum width of multiple pipe trench.

Trenches shall be of such extra widths, when required, as will permit the convenient placing of timber supports, sheeting and bracing and handling of specials.

If during excavation the width of the trench at 300 mm above the top of the pipe becomes greater than the above mentioned values, the Contractor may be instructed by the Engineer to change the pipe bedding details and any additional cost of implementing such instructions shall be borne by the Contractor.

The Contractor shall be responsible for the safety of all his trench excavations and all excavated pit sides, trench walls or slopes shall be stable and established with respect to all current international safety standards.

C.4 Trench Excavation In Fill

If pipe is to be laid in recently filled material, the material shall first be placed to the top of the fill or to a height of at least 30 cm above the top of the pipe, whichever is the lesser. Particular care shall be taken to ensure maximum consolidation of material under the pipe location. The pipe trench shall be excavated as though in undisturbed material.

C.5 Trench Bridging

The Contractor shall, at his own expense, provide suitable and safe bridges and other crossings where required for the accommodation of travel and to provide access to private property during construction and shall remove such said structures thereafter.

2.10.12 EXCAVATION FOR FOUNDATIONS AND SUB-STRUCTURES

A. Excavation for foundations and sub-structures shall be carried out to the lines and grades shown in the Drawings. The excavation shall be of sufficient dimensions to permit construction of forms and bracing for foundations and substructures and installation of waterproof materials or any other trade as called for.

B. The elevation of the bottom of foundations as shown in the Drawings shall be considered as approximate and indicative only.

C. The Engineer shall order in writing any change in dimensions or elevations of foundations as may be deemed necessary to secure a firm foundation of uniform density.

D. After each section of excavation is completed, the Contractor shall notify the Engineer to that effect and no concrete blinding course for foundations shall be poured until the Engineer has approved the excavation and the character of the foundation material.

E. Any method of excavation shall be approved provided it does not disturb the foundation layers or adjacent structures.

F. If during the progress of the work, loose or improperly compacted soil or such other material as the Engineer considers unsuitable is encountered below structure foundation level, or adjacent thereto, such material shall be removed within the limits as directed by the Engineer. The resulting void shall be backfilled with either plain concrete or with an approved material compacted to a density not less than 95% of the maximum dry density. The Engineer shall specify the system of backfilling to be employed at each location.

G. Any such excavation encountered which would in the opinion of the Engineer be detrimental to load distribution of new foundations to the underlying soil, shall be excavated and backfilled with plain concrete, as directed by the Engineer.

H. All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface, either level, stepped, or serrated as directed by the Engineer. All seams or crevices shall be cleaned and grouted. All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed.

I. When the foundation material is soft or mucky or otherwise unsuitable as determined by the Engineer, the Contractor shall remove the unsuitable material and backfill with approved granular material or with plain concrete for high load carrying structures. The foundation fill shall be placed and compacted in 200 mm layers up to the foundation elevation. Compaction shall comply with these specifications.

J. Any surplus excavated material or excavated material unsuitable for fill or backfill, shall be carted away and deposited in an approved dumping area.

2.10.13 EXCAVATION NEAR EXISTING UTILITY LINES AND SERVICES

A. The Contractor's attention is brought to the fact that there exists along the projected sewerage line all kinds of existing utilities and services, mainly electrical and telephone cables, water lines, sanitary and storm water sewers, box and pipe culverts, manholes etc. Only a part of these services have been approximately located on the drawings and the Contractor shall be responsible for establishing the exact position of all utility lines and services liable to interfere with the new construction, prior to carrying out construction in the vicinity.

B. The Employer accepts no responsibility for the reliability, completeness or otherwise, of the information available and the Contractor shall carry out as necessary, trial holes or trial trenches to locate such existing services and any other buried structures, where information can not be derived from records or surface indications. When such trial holes and trenches fall within the limits of the Contract excavation, the Contractor shall receive no additional compensation, the work being understood to be included as part of these excavations. If trial excavations are ordered beyond the limits of the Contract excavations, they shall be measured and paid for in accordance with the contract.

C. As the excavation approaches pipes, conduits, or other underground structures, digging by machinery shall be discontinued and the excavation shall be done by means of hand tools, as directed. Such manual excavation, when incidental to excavation, shall be deemed to be included in the Contractor's rates and prices for excavation.

D. Notice of Intent

The Contractor shall file a Notice of Intent with the service authorities who have services at the site or works in progress at the site at least six weeks before he desires to carry out any work near, above, or under their services. He shall submit a detailed programme for each area in which the work shall be commenced and the anticipated date of commencement in addition to a report, signed by the Engineer, the service authority Engineer and the Contractor confirming the Notice of Intent.

E. Shop Drawings

Prior to commencing construction and subsequent to the contractor's determination of the location of the existing utility lines, the Contractor shall prepare and submit to the Engineer for his review shop drawings complete with the description of the procedure, materials and related date of the Contractor's proposed method of protection for said utility lines. Review and comments by the Engineer shall in no way relieve the Contractor of the full responsibility for all protection and precautions required during the Works.

F. Protection of Existing Structures and Utilities

F.1 The Contractor shall be responsible for the care and protection of all existing utilities or other facilities, buildings and structures which may be encountered in or near the area of work. Temporary support, adequate protection and maintenance of all underground and surface utilities encountered in the progress of the work shall be furnished by the Contractor at his expense and under the direction of the Engineer and the service authority. Any structures that have been disturbed shall be restored immediately.

F.2 The Contractor shall be responsible for bracing and support of structures, utilities and services to prevent settlement, displacement, or damage to same.

F.3 The Contractor shall remove and cap abandoned utilities in accordance with service authority direction and as directed by the Engineer. The method of capping the lines shall conform to the requirements of the utility or service authority.

G. Maintaining Utilities in Operation

The Contractor shall ensure that all existing utilities such as electric power, water, sanitary sewers, road lighting and telephone services shall not be interrupted during the course of this project. This may require the establishment of temporary service connections including sewer house connections until the Works are complete and all reinstatement of utilities is made.

H. Relocation and Replacement of Existing Services and Structures

H.1 Apart from clarifying and locating positions to prevent damage to existing services, the scrutiny is required to clarify those services which might conflict with the Permanent Works.

H.2 Where this conflict would arise, the Engineer will consider if an amendment to the design can be made, or if a diversion of the existing main service is needed. In order that any such diversion be made in advance of the construction, it is essential that the scrutiny of these services be made well in advance of any excavation works commencing and the Contractor shall be deemed to have allowed in his rates for complying with the above.

H.3 Where encountered services and utilities are in conflict with the Permanent Works, the relocation of such services and utilities must be approved in detail by the Engineer.

H.4 All work in connection with removal and relocation shall be carried out by the contractor under the supervision of the Engineer and/or the concerned utility authority. Alternatively, the concerned authority may carry out the work itself, in which case the contractor will afford all reasonable assistance and access during the undertaking of the work.

H.5 All relocation work shall be designed by the Contractor in conjunction with the utility authority and shall comply in all respects with their current regulations and specifications. The Contractor must allow for the preparation of all shop drawings and for obtaining approvals for the designs from concerned authorities.

H.6 For each case of main conflict of existing services with the Permanent Works, the Contractor shall inform the Engineer by writing and prepare, for his approval entirely at his own expense, suitable scale drawings of his proposed diversion or amendment to the design.

H.7 In addition to the scrutiny referred to above, the Contractor shall take all reasonable precautions to prevent damage to existing buried main services and connections to buildings. Any damage shall be repaired at the Contractor's expense.

H.8 In removing existing pipes or other structures, the Contractor shall use care to avoid damage to materials and the Engineer shall include for payment only those new materials which, in his judgment are necessary to replace those unavoidably damaged.

H.9 The structures to which the provisions of this Clause shall apply include utility lines and cables and other structures which in the opinion of the Engineer will impede progress to

such an extent that satisfactory construction cannot proceed until they have been changed in location, removed (to be later restored), or replaced. When fences interfere with the Contractor's operations, he shall remove and (unless otherwise instructed by the Engineer) later restore them to at least as good a condition as that in which they were found immediately before the work was begun, all without additional compensation. The restoration of fences shall be done as promptly as possible and not left until the end of the construction period.

2.05.14 EXCAVATION

The Contractor shall remove only as much of any road pavement as is necessary for the execution of the work. All existing road pavement to be removed for excavation purposes shall be neatly saw cut with appropriate pneumatic tools to leave a neat square edge suitable for proper reinstatement on completion of the works. Any overbreakage or damage to the road surface caused by the Contractor's operations shall be neatly cut back to a sound surface, to the approval of the Engineer, prior to reinstatement of the road, all at the expense of the Contractor. Reinstatement shall be carried out in accordance with the relevant section of these specifications.

2.05.15 CARE AND RESTORATION OF ROAD PAVEMENTS AND STRUCTURES

A. On paved surfaces the Contractor shall not use or operate tractors, bulldozers, or other power-operated equipment the treads of wheels of which are so shaped as to cut or otherwise injure such surfaces.

B. All pavements which have been damaged by the Contractor's operations shall be restored to a condition at least equal to that in which they were found immediately before work was begun all to the approval of the Engineer.

C. The restoration of existing property or structures shall be done as promptly as practicable and shall not be left until the end of the construction period and shall be at the Contractor's expense. Restoration shall be carried out in accordance with the relevant section of these specifications.

2.05.16 PREPARATION AND INSPECTION OF EXCAVATIONS

Bottoms of excavations shall be leveled, well rammed and consolidated before laying of pipes, placing concrete foundations etc., all to the approval of the Engineer.

If excavations are carried out below the levels indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted, selected fill if the excavation is for a pipeline, or with Class B concrete if the excavation is for a masonry or concrete structure, all to the satisfaction of the Engineer.

2.05.17 FILLING AND BACKFILLING FOR PIPE TRENCHES AND MANHOLES

A. General

A.1 In general and unless other material is indicated on the Drawings or specified, material used for backfilling trenches and excavations around structures shall be suitable

excavated material. Suitable material shall be cohesionless material free from organic matter, perishable material, chemically contaminated material and stones exceeding 50mm in size and shall have a plasticity index not exceeding 10 and a Liquid Limit not exceeding 40.

A.2 If there are insufficient quantities of suitable material obtained from excavations, then the Contractor shall obtain additional quantities of such suitable material from approved borrow pits. The Selected Fill and Suitable Fill materials quantities supplied by the Contractor from borrow areas shall be paid to the Contractor at the rates shown in the Bills of Quantities.

A.3 Wherever a percentage of compaction for backfill is indicated or specified, it shall be the percent of maximum density at optimum moisture content as determined by Method D of ASTM D1557 latest editions Standard Methods of Test for Moisture-Density Relations of Soils Using 10 lb. Rammer and 18 in. Drop. If the percentage of compaction is not indicated, it shall be understood to be 95 %.

A.4 Filling and backfilling shall start only after preparation and inspection of trench excavations and testing of the structures to be backfilled has been performed and approval by the Engineer has been secured.

B. Backfilling Around Manholes, Chambers and Other Related Structures

B.1 Excavated areas around manholes, chambers and other related structures shall be backfilled with suitable materials approved by the Engineer. Backfill materials shall be placed in horizontal layers not exceeding 200 mm in depth and compacted in accordance with these Specifications. Each layer shall be moistened or dried as required and thoroughly compacted as specified. The maximum size of particle allowed in the backfill within one metre of structures shall be 50 mm. Unless otherwise stated elsewhere or shown on drawings, material approved for filling and Backfilling shall conform to AASHTO M 145 groups A-1-a, A-1-b, A-3, or A-2-4.

B.2 Where indicated on the Drawings suitable backfill material behind stuctures shall be AASHTO M 145 group A-1-a, A-1-b or A-2-4.

B.3 Potable water shall be used in backfilling excavation. Backfill shall be placed to the original ground level or as indicated on the Drawings.

B.4 Backfill shall not be placed against or on any structure until such structure has attained the strength to safely support the loads to which it will be subjected. Unequal soil pressures shall be avoided by depositing the backfill evenly around the structure. For walls with fill on both sides, the difference in the level of backfill shall not be such as to endanger the safety of the walls.

B.5 Walls with fill on both sides shall have the fill constructed such that the difference in the top elevation of the fill on the two sides does not exceed 60 cm at any time.

C. Fill and Backfill Under Manholes, Chambers and Other Related Structures

C.1 Unless otherwise indicated or specified, all fill and backfill under manholes, chambers and other related structures shall be compacted well graded screened gravel having a maximum size of 5 cm. The gravel shall consist of clean, hard and durable particles or fragments, free from dirt, vegetable, or other objectionable matter and free from an excess of soft, thin, elongated, laminated or disintegrated pieces. Crushed rock of suitable size and

grading may be used instead of screened gravel. The specification which follows shall apply whichever material is used.

C.2 The fill and backfill materials shall be spread in layers of uniform thickness not exceeding fifteen (15) cm and then shall be thoroughly compacted by means of a suitable vibrator or mechanical tamper to attain the specified percentage of compaction specified in this section

D. Backfilling Pipe Trenches

D.1 All backfilling within roadways and footpath limits, tiled areas and underneath, around and over concrete structures shall be compacted to a minimum of 95% of AASHTO T180 density. Backfilling all other areas shall be compacted to a minimum of 90 % of AASHTO T180 density. All compaction shall be done in layers not exceeding 150mm in thickness and fill shall be brought up simultaneously on all sides of the excavation.

D.2 Excavations shall be backfilled above pipe encasement with suitable excavated or imported material without unnecessary delay, but not until pipes and manholes and other construction details have been tested and accepted by the Engineer. Suitable material shall be cohesionless material free from organic matter, perishable material, chemically contaminated material and stones exceeding 50mm in size and shall have a plasticity index not exceeding 12.
Where required and/or directed by the Engineer, a timber grillage shall be used to break the fall of material dropped from a height of more than 1.50 meters.

D.3 Pieces of bituminous pavement shall be excluded from the backfill unless their use is expressly permitted, in which case they shall be broken up as directed.

D.4 As soon as practicable after the pipes have been laid and the joints have acquired a suitable degree of hardness, if applicable, or the structures have been built and are structurally adequate to support the loads, (including construction loads) to which they will be subjected, the backfilling shall be carried out. Under no circumstances shall water be permitted to rise in non-backfilled trenches after the pipe has been placed.

D.5 Trenches shall not be backfilled at pipe joints until after that section of the pipeline has successfully passed any specified tests required.

D.6 The zone around the pipe shall be backfilled with the materials and to the limits indicated on the Drawings.

D.7 Trenches for pipes shall be backfilled by selected fill to a depth of 300 mm above the top of the pipe by hand, using the specified materials for pipe bedding and surround and shall be thoroughly compacted by careful hand tamping in layers 15 cm in depth up each side. Above the 300 mm, approved mechanical means such as water-jetting, puddling or tamping shall be used for compaction. The Contractor shall use special care in placing this portion of the backfill so as to avoid damaging or moving the pipe.

D.8 Backfilling should not start before 24 hours after placing any concrete. Heavy compactors and any traffic loadings should not be allowed before 72 hours after placing any concrete.

D.9 Whatever method of compacting backfill is used, care shall be taken that stones and lumps are not nested and that all voids between stones are completely filled with fine

material. The Contractor shall, as part of the work done under the items involving earth excavation and rock excavation as appropriate, furnish and place all other necessary backfill material.

D.10 All voids left by the removal of sheeting shall be completely backfilled with suitable materials and thoroughly compacted.

D.11 When required, excavated material which is acceptable to the Engineer for use in the pavement sub-base course shall be placed at the top of the backfill to such depths as may be specified elsewhere or as directed.

D.12 Necessary precautions shall be taken during backfilling to ensure that pipes, manholes and other structures are not damaged. Any spaces left by the withdrawal of timbering shall be properly filled and compacted immediately.

D.13 Follow manufacturer's recommendations for backfilling around GRP pipes and concrete pipes. Strict adherence to the manufacturer's instructions for laying and backfilling, under, around and above the pipe and as approved by the Engineer.

E. Selected Fill Material for Pipe Trenches (Granular Fill)

E.1 Selected fill material as bedding and surround to pipes shall consist of approved granular material (crushed rock aggregates), which shall exclude particles larger than 14 mm in size. The material shall be capable of being compacted to a solid mass and achieve a 95% compaction Proctor Test.

E.2 Selected fill material shall comply with group type GW, GP, in compliance with ASTM D 2487.

E.3 Selected fill material shall not contain ashes, cinder, refuse, rubbish, organic material, or the like. All selected material used for backfilling shall be placed in layers not exceeding 150 mm and compacted as detailed in this section of the Specifications.

E.4 Excavated local sand material may be used if satisfactory, subject to the approval of the Engineer.

F. Suitable Fill for Pipe Trenches (Backfill)

F.1 Suitable fill material to backfill pipe trenches shall consist of approved cohesionless material, sand or crushed rock aggregates (0-50mm) free from (organic matter, perishable material, chemically contaminated material and stones exceeding 50mm in size) and shall have a plasticity index not exceeding 10 and a Liquid Limit not exceeding 40.

F.2 If there are insufficient quantities of suitable material obtained from excavations, then the Contractor shall obtain additional quantities of such suitable material from approved borrow pits. The Selected Fill and Suitable Fill materials quantities supplied by the Contractor form borrow areas shall be paid to the contractor at the rates shown in the Bill of Quantities.

2.05.18 MEASUREMENT

A. Excavation is to be understood as unclassified for "Trench Excavation" and 'Structural Excavation".

B. Trench excavation for water, sanitary sewerage (waste water), storm water, culverts and channels shall be measured under "Trench Excavation for Pipes including backfill" in linear meter.

C. All excavations including excavation to reduce levels shall start from the subgrade levels of all roadway excavations. Starting levels of excavations to be carried out in areas already excavated and measured shall be the bottom level of such excavation previously measured (Roadway works).

D. Length of trench shall be the same length of item to be laid in, deducting all excavation measured under other items, or voids where trench is not carried out.

E. The maximum width of trench for water, sewerage and storm water lines shall be as stated in this Specification. Trenches to be used for more than one item, shall be so described stating the number and size of each utility within the trench.

F. The average depth of trench shall be the difference between the average natural ground level and the average invert level between two stations plus the thickness of the pipe and bedding as specified. The average natural ground level is defined by using the levels at the two stations only and the average invert level is defined by using the invert levels of the starting and ending points of the two stations. The two stations mentioned above are any structure at the starting and ending points of each pipe section (normally between two manholes) with no structure whatsoever interrupting this pipe or cable section.

G. Additional trench excavation in rock areas to provide greater depth of sand bed to pipes shall be deemed to be included in the rates for excavation.

H. Excavation for culverts, manholes, structures, etc…, shall be measured under "Structural Excavation including backfill" in cubic meters (Refer to section 2.09). The volume measured shall be the volume which is to be either occupied by or vertically above any part of works to be excavated. Additional excavation necessary to provide working space or for shoring shall be measured up to 0.5 m from the reinforced concrete edges. The volume of such excavations shall be computed as the product of the resulting horizontal or plan area, and the average depth from the starting level to the underside of the base or blinding layer.

I. In addition to what is stated before in these preambles and in the description of the items, the rates of excavation items shall include but not be limited to:

a. Excavating in any type of ground, including rock, or materials (concrete, pavement, etc…) structural fill, contaminated fill, clay or others.

b. Excavating by hand or machine.

c. Dewatering operations necessary for keeping excavation free from water whether groundwater, sea water or any other sources.

d. Leveling or grading and compacting bottom of excavations.

e. All necessary double handling of excavated materials.

f. Trimming or planking and strutting sides, bracing, driving steel sheeting or piling (steel or reinforced concrete) and any other temporary or permanent supports to sides of excavation and to existing structures and utilities around the trench.

g. Selecting excavated materials, backfilling and compacting.

h. Removal of and carting away surplus materials and storage of selected backfill including all labour and transport cost involved in removing such material to an approved storage area away from the site and it's subsequent re-transport back to the site.

i. Any additional excavation beyond 0.5m necessary to provide working space or shoring.

j. Exposing by hand digging or special equipment, supporting, protecting and maintaining existing services and utilities.

k. Making good all work disturbed.

l. Temporary supports to roads or structure as required by the Engineer and trench bridging.

m. Any backfilling, concrete fill or other works required to be carried out to excavations as a result of excavations beyond the specified line and level.

n. Working above or under, alongside, across or near existing utilities and utility structures including pipes, cables, ducts, duct banks, manholes, septic tanks, chambers, services, valves, thrust blocks, drainage channels, gully inlets, and the like, and maintaining existing services in operation. Repair and reinstatement of all utilities affected by the excavation, payment of fines resulting from damage to any utility, temporary support of any utility if deemed necessary, maintaining existing services in operation and all necessary works in connection with the protection and safety of adjacent structures, utilities and services, and all other incidental works.

o. Reinstatement of all surfaces damaged by traffic due to the Works.

J. All backfill work to make up levels shall not be measured separately.

K. Providing and operating all pump and pump stations for overpumping and flow diversion of sewage as specified shall be measured and paid separately.

L. No separate payment shall be made for fill work using surplus excavated materials, all costs in respect of selecting suitable material from excavations and transporting same to temporary stockpiles, re-excavating from stockpiles, loading, hauling, off loading, spreading, leveling, shaping, watering and compacting and performing all tests as required by the Specifications, all double handling of materials and all other works necessary in accordance with the Engineer's requirements and the Specifications shall be deemed to be included in the rates of excavations.

M. The rates shall include for all costs in respect of payment of charges for materials obtained from borrow pits, excavation, loading, hauling, off loading, leveling, watering, compacting, double handling, shaping and performing all tests as required by the

Specifications, all in accordance with the Specifications and to the approval of the Engineer.

N. The pavement at the limits of the excavated trench and area is to be cut 0.5m from each side and restored accordingly mainly for traffic purpose, unless otherwise instructed by the Engineer.

This item shall consist of supplying, transporting, storing, spreading and compacting in trenches and in subsequent layers the following:

- Aggregate base course (25 cm minimum),
- Prime coat (average 1 lit/m^2) and
- Bituminous surface course (5cm).

This item shall be measured in square meters and shall be the net theoretical value as measured. Deduction shall be made for intercepting structure exposed area such as manholes covers, etc…

SECTION 3: SUB BASE AND BASE COURSES

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SECTION 3.01 MATERIALS FOR SUB-BASE AND BASE COURSES

3.01.01 SCOPE

A. This section covers the requirements for the characteristics, source, supply and storage of sub base and base course pavement materials

B. Materials specified for use in the construction of sub-base and base courses for flexible and rigid pavements include the following:

- Screened or partially crushed granular material consisting of well graded gravel, crushed stone or crushed gravel for sub-base course construction.
- Crushed stone for base course construction.
- Stabilizing materials including Portland cement, bitumen and lime to be used where specified in sub-base and base courses and in subgrades.

3.01.02 GENERAL

A. Sources and Production

A.1 All material sources and the quality of materials proposed for use in the Works shall be approved by the Engineer prior to procuring or processing material from such sources. Inspection, sampling, testing and retesting shall be at the Contractor's expense in accordance with Part 1- Section 4.6: Samples and Approvals and as specified hereunder for specific materials.

A.2 Location of sources and manufacturers of materials in accordance with the requirements of the Specification is the responsibility of the Contractor, who shall produce the required granular materials and aggregates at the rates and in the quantities necessary to complete the Works on time.

A.3 The Contractor shall have satisfied himself as to the location, suitability and quantity of materials available, the extent of work necessary to obtain the material available, the work required to open the quarry, crush, and screen and wash the materials and the length of haul to the Site.

A.4 Prior to starting quarrying or borrow pit operations the Contractor shall obtain written permission from the relevant authorities and owners.

A.5 All screening or crushing and screening plant shall be approved by the Engineer prior to being put into operation. If any plant fails to perform as intended the Contractor shall either rectify the defects in the existing plant to the satisfaction of the Engineer or provide suitable alternatives.

A.6 Approval of the crushing and screening plants and other equipment shall not relieve the Contractor of his responsibilities in respect of producing granular materials and aggregates which conform to the Specification and in the quantities required for the completion of the Works on time.

B. Stockpiling

B.1 Storage and handling of all materials shall conform to the relevant requirements of Part 1 of the Specification, Section 4-6 Samples and Approvals. Materials shall be stored on hard, clean, well drained surfaces as approved or as directed by the Engineer.

B.2 All topsoil in stockpile areas shall be stripped and stored in berms or bunds less than 1.2m in height prior to stockpiling of materials. The prepared 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.

B.3 Stockpiling procedures shall not result in noticeable degradation or segregation of the stockpiled material, the introduction of foreign materials into the stockpile or coning. Heights of granular material and aggregate stockpiles shall not exceed 3 m.

B.4 Granular material that, in the opinion of the Engineer, has been adversely affected by stockpiling or handling procedures shall not be incorporated in the Works, regardless of previous approval of such material until the deficiencies have been rectified in an acceptable manner.

B.5 Stockpile areas shall be reinstated, including the spreading of stored topsoil, to the satisfaction of the Engineer on completion of stockpiling activities

C. Sampling and Testing

C.1 Sampling and testing procedures shall conform to the relevant requirements of Part 1- Section 4-6: Samples and Approvals of the Specification and with the following requirements.

C.2 The Contractor shall submit to the Engineer, at least 10 days prior to the scheduled beginning of crushing and screening operations, a statement of origin and composition of all stone and/or gravel aggregates and granular materials proposed for use in the Works.

C.3 In order to ascertain the properties of granular and 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 or borrow pit operations. The representative samples shall be taken by the Contractor in the presence of the Engineer.

C.4 Tests performed by the Contractor shall be used for assessing the locations, extent of deposits and quantities of materials that will conform to the Specification when properly processed but shall not obviate the need for further testing if required by the Engineer. Approval of specific sources of materials shall not be construed as final approval and acceptance of materials from such sources.

C.5 The Contractor shall conduct necessary tests on materials in field laboratories in the presence of the Engineer and the Contractor's Materials Engineer.

C.6 Processed materials shall be tested and approved before being stockpiled on Site or incorporated in the Works and shall be inspected and tested at any time during preparation, storage and use. Materials awaiting testing and approval shall not be unloaded and mixed with materials previously approved. If the grading or quality of any materials delivered to the Site does not conform to requirements of the Specification, the Engineer shall reject these materials.

C.7 Materials shall be tested in accordance with Table 3.1.1 after mixing with water at the mixing plant.

C.8 Samples shall satisfy all specified test requirements. The Contractor shall permit the Engineer 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. Materials not complying with the Specification, whether in place or not, shall be removed promptly from the Site. The Contractor shall furnish all necessary labour, transport, tools and equipment required by the Engineer for such inspections.

Table 3.1.1: Required Tests and Minimum Repetition for Sub Base and Base Course Materials

Source of Materials	
Required Tests	**Repetition Required for all Tests**
1. Gradation of Materials 2. Plasticity Index	• Test for each source and every 2000 m^3
1. Abrasion 2. C.B.R. 3. Soundness 4. Percentage of fractured Grains (Base course) 5. Clay content 6. Sand equivalent	• When material source or process changes and when otherwise instructed by the Engineer

3.01.03 GRANULAR MATERIAL FOR SUB-BASE

A. Granular material for use in sub-base courses shall be a naturally occurring gravel, blended as necessary with fine or coarse material and screened to produce the specified gradation. Crushing of natural granular material shall not normally be required, unless for meeting the grading requirements, producing a higher quality sub-base with improved mechanical stability or when shown on the Drawings.

B. Gravel shall consist of hard, durable and sound rock fragments, free from dirt, organic matter, shale and other deleterious substances.

C. Granular materials for sub-base shall meet the requirement of class A or B as shown in table 3.1.2, 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 the Drawings or as selected by the Engineer. The actual gradation shall be continuous and smooth within the specified limits for each Class.

Table 3.1.2: Gradings of Granular Material by Class

Sieve Designation (Square Openings)	**Percent by Weight Passing**	
	Class A	**Class B**
50 mm (2 in.)	100	100
25 mm (1 in.)	-	75 - 95
9.5 mm (3/8 in.)	30 – 65	40 - 75
4.75 mm (No. 4)	25 – 55	30 - 60
2.00 mm (No. 10)	15 – 40	20 - 45
0.425 mm (No. 40)	8 – 20	15 - 30
0.075 mm (No . 200)	2 – 8	5 - 20

D. The material shall contain a maximum 5% clay content at any stage of construction when tested in the Hydrometer Test in accordance with AASHTO T88.

E. The loss in weight of granular material shall not exceed 50% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

F. The granular material shall have a 4-day soaked CBR of not less than 30 when compacted at 100% of modified proctor AASHTO (T 180-D) and tested in accordance with AASHTO T 193.

G. When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and the percentage loss in weight after 5 cycles shall not exceed 12 % in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

H. The portion of granular material, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (L.L.) of not more than 25 and a plasticity index (P.I.) not greater than 6 when tested in accordance with AASHTO T 89 and T 90.

I. If additional fine material is required to correct the gradation the granular material, or for adjusting the L.L. or P.I. of the fraction passing 0.425 mm (No 40) sieve, it shall be uniformly blended and mixed with the granular material. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or slag, if naturally occurring fine material is not available.

3.01.04 AGGREGATES FOR BASE COURSES

A. Aggregates for use in base course construction shall be either crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel or sand. Aggregate shall be washed if necessary to remove excessive quantities of clay, silty clay or salts.

B. Crushed stone shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter and shall contain not more than 8% of flat, elongated, soft or disintegrated pieces.

C. Crushed gravel shall consist of hard durable stones, rocks and boulders crushed to specified sizes and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt or other objectionable matter

D. The method used in the production of crushed gravel shall provide a uniform material quality. The crushing of the gravel shall result in a product having at least 90% by weight of particles with at least one fractured face. All stones, rocks, and boulders of inferior quality occurring in the pit shall be discarded.

E. Any material passing the 4.75 mm (No. 4) sieve and produced in the crushing process may be incorporated in the base material up to the grading limits required for the base course aggregate.

F. Crushed aggregate for base course shall meet the requirements of Class A or Class B gradings as shown in Table 3.1.3 when tested in accordance with AASHTO T 27 after mixing with water, just before spreading and prior to compacting. The class of aggregate to be used shall be as shown on the Drawings or as selected by the Engineer. The actual grading shall be continuous and smooth within the specified limits for each Class. Gap graded aggregate shall not be accepted. If gradings are tested after compaction a tolerance of 3% shall be allowed in the upper limit for the percentage of material passing the 200 sieve.

Table 3.1.3: Grading of Base Course Aggregate by Class

Sieve Designation (Square Openings)	Percent by Weight Passing Class A	Class B
50 mm (2 in.)	100	-
25 mm (1 in.)	75 - 95	100
9.5 mm (3/8 in.)	40 - 75	50 - 85
4.75 mm (No. 4)	30 - 60	35 - 65
2.00 mm (No. 10)	20 - 45	25 - 50
0.425 mm (No. 40)	15 - 30	15 - 30
0.075 mm (No . 200)	5 - 20	5 -15

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

H. The loss in weight shall be in the range of 45% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test) and the sand equivalent shall be a minimum of 43% when tested in accordance with AASHTO T176.

I. The crushed aggregate base course material shall have a 4-day soaked CBR of not less than 80 when compacted at 100% of modified proctor AASHTO (T180-D) and tested in accordance with AASHTO T 193.

J. When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and the loss by weight shall not exceed 12% in the case of the sodium sulphate test and 18% for the magnesium sulphate test.

K. The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a Liquid Limit (L.L.) of not more than 25 and Plasticity Index (P.I) of not more than 6 when tested in accordance with AASHTO T 89 and T 90.

L. If additional fine material is required to correct the aggregate grading or for adjusting the L.L. or P.I. of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material at the crushing plant or by a method approved by the Engineer. Reworking of the material in situ to obtain the specified gradation shall not be permitted. Additional fine material shall only be obtained from the crushing of stone, gravel or natural material.

3.01.05 STABILIZING AGENTS

A. Cement as Stabilizing Agent

Cement shall be Portland cement conforming to AASHTO M 85 Type II, or sulphate resistant Portland cement conforming to AASHTO M 85, Type V.

B. Bitumen as Stabilizing Agent

B.1 Bitumen may include straight run (penetration grade) bitumen; RC cutback bitumen, MC cutback bitumen, or cationic emulsified bitumen. Penetration grade, cutback bitumen and emulsified bitumen shall conform to all relevant requirements herein.

B.2 The selection of a suitable bitumen will depend on the properties of the material to be stabilized and shall be subject to laboratory and field trials by the Contractor, under the supervision of the Engineer.

B.3 When the material moisture content is high and material must be dried, penetration grade bitumen or viscous cutback bitumen shall be used and materials mixed using appropriate plant.

B.4 When the natural moisture content of the material is low, cutback bituminous or emulsified bitumen shall be used.

C. Lime as Stabilizing Agent

C.1 Hydrated lime (calcium hydroxide) and quicklime (calcium oxide) shall conform to AASHTO M 216 Mixing of different brands of lime or use of lime from different mills shall not be permitted.

C.2 Lime slurry shall be a homogeneous pumpable mixture of lime and water. Slurry shall be a premixed material in which the lime solids content shall be not less than 30 % by weight.

3.01.06 MEASUREMENT

Granular aggregate materials for Sub-Base and Base Course shall be measured as prescribed in the appropriate Sections of these Specifications.

SECTION 3.02 GRANULAR SUB-BASE COURSE

3.02.01 SCOPE

The work covered in this Section consists of furnishing granular sub-base material of the required class, mixing, spreading on prepared subgrade, compacting and finishing, all as and where shown on the Drawings

3.02.02 MATERIALS

All materials shall conform to the relevant requirements of Section 3.01 - Materials for Sub-Base and Base Courses, in respect of granular material for sub-base construction and the particular requirements for sub-base courses detailed on the Drawings.

3.02.03 SUBGRADE SURFACE PREPARATION

A. The subgrade shall have previously been constructed in accordance with the requirements of Section 2.07: Subgrade Construction, properly maintained and kept well drained.

B. The minimum thickness of sub-base shall be as shown on the Drawings. At transition points, such as specified changes of sub-base thickness, areas adjacent to structures and at tie-ins to existing pavements the subgrade shall be adjusted to a depth sufficient to permit construction of the sub-base course to the specified finished levels and thicknesses. Transitions shall be of sufficient lengths to avoid abrupt changes of grade that compromise drainage paths in the sub-base and shall be within plus or minus 3 % of the final design grade unless otherwise directed by the Engineer. Surplus material shall be removed and disposed of.

C. The subgrade shall be inspected and approved immediately prior to commencement of sub-base construction. Any soft, yielding material shall be removed and replaced by topping material approved by the Engineer. Holes, depressions and other irregularities shall be made good as directed by the Engineer and the subgrade recompacted and finished to receive the sub-base course.

3.02.04 EQUIPMENT

Equipment used to handle, place, spread, water, compact and finish sub-base shall conform to the requirements of Part 1 of the Specification - Section 4-4: Contractor’s Plant and Equipment and with the Contractor's approved Work Programme.

3.02.05 CONSTRUCTION OF TRIAL SECTIONS

A. If directed by the Engineer, before commencement of sub-base construction, the Contractor shall lay and compact trial sections of varying thickness of sub-base. Each trial section shall be 2 lanes wide by 50 metres long at approved locations on or close to the Site. Each trial section shall be laid using the same materials, mix proportions, mixing, spreading and compaction equipment and construction procedures proposed for use in the Works.

B. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth measurements that will result in the specified compacted layer depths, the field moisture content and the relationship between the number of compaction passes and the resulting density of the sub-base material.

3.02.06 CONSTRUCTION

A. Stockpiling of Granular Material

Stockpiling procedures shall conform to the relevant requirements of Section 3.01 - Materials for Sub-Base and Base Courses.

B. Mixing and Spreading

B.1 All components of sub-base course material shall be mixed thoroughly and uniformly with water in situ. The amount of water added shall be sufficient to maintain the material within the specified moisture content range at the time of compaction. Water shall only be added as necessary during placing and compaction of sub-base material. Watering of granular material in stockpiles or in trucks before or during delivery to the Site shall not take place.

B.2 The sub-base material shall be placed on the subgrade in a uniform layer or layers not exceeding 200 mm thickness (after compaction).

B.3 The Engineer shall permit compaction of sub-base in layers of up to 300mm if heavy duty vibratory compaction equipment is used and compaction tests with appropriate testing equipment indicate that the specified compaction standard will be attained and uniform throughout the thickness of the layer.

B.4 Sub-base material shall be placed to the required width using a self-propelled spreader or a motor grader equipped with blade extensions. Water shall be applied by approved spraying equipment and thoroughly mixed with the sub-base material.

B.5 The material shall not be handled in such a way as to cause segregation. If the spreading equipment causes segregation in the material or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the equipment, the use of such equipment shall forthwith be discontinued and replaced by a spreader or grader capable of spreading the material in a satisfactory manner.

B.6 All segregated material shall be removed and replaced with well-graded material. Skin patching shall not be permitted. Only minor surface manipulation and

watering to achieve the required surface tolerances shall be permitted during the compaction process.

B.7 Neither hauling nor placement of material shall be permitted when, in the judgment of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of the subgrade or cause contamination of the sub-base material.

C. Compaction

C.1 The Contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If the Contractor delays placing of succeeding layers of material to the extent that additional water is required to prevent ravelling or excessive drying the application of such water shall be carried out as directed by the Engineer and at the Contractor's expense.

C.2 The sub-base material shall be compacted by progressing gradually from the outside towards the centre, with each succeeding pass uniformly overlapping the previous pass.

C.3 Rolling shall continue until the entire thickness of each sub-base layer is thoroughly and uniformly compacted to 100 % AASHTO T 180 (Method D) maximum density. Final rolling of the completed course shall be completed by a self-propelled roller. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape. When additional water is required, it shall be applied by a method approved by the Engineer.

C.4 Any areas inaccessible to normal compaction equipment shall be compacted by portable mechanical tampers until the required standard of compaction is achieved.

C.5 Each layer shall be completely compacted and approved prior to delivery of materials for the subsequent layer.

C.6 Prior to placing a subsequent layer, the existing surface shall be made sufficiently moist as directed, to ensure a proper bond between layers.

C.7 The edges and edge slopes of the sub-base course shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes free of loose material.

C.8 Material which has dried out prior to final compaction or which has dried and de-compacted subsequent to final compaction shall be watered and recompacted using equipment and procedures approved by the Engineer. If the Contractor is unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerances, the Contractor shall remove the material and reconstruct the sub-base course on a re-approved subgrade.

D. Tolerances

D.1 The fully compacted and completed sub-base course shall conform to the lines, grades and cross sections as shown on the Drawings.

D.2 The levels of the finished sub-course shall be checked by the Contractor in the presence of the Engineer at maximum intervals of 10 m and at intermediate points as directed.

D.3 The tolerances on levels of the finished surface shall be plus 10 mm to minus 20 mm. A minus tolerance shall be compensated by the addition of material in the proceeding layer.

D.4 When the finished surface is tested with a 3 m long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed 10 mm.

D.5 All areas which exceed the specified tolerances shall be corrected by removing the defective sections of sub-base and reconstructing them or, if approved by the Engineer, by the addition of new material, mixing, re-compacting and finishing to the specified standard.

E. Maintenance of Completed Sub-Base

Following completion and acceptance of the sub-base course, it shall be maintained by the Contractor at his own expense. The sub-base shall be bladed, broomed and otherwise maintained, keeping it free from ravelling and other defects until such time as the base course is placed. Water shall be applied at such times and in such quantities as directed by the Engineer.

3.02.07 TESTING

A. Materials at source or at the stockpile area shall be tested in accordance with Section 3.01 Materials for Sub- Base and Base Course. Materials laid and compacted shall be tested in accordance with Table 3.2.1 below and, if found satisfactory, shall be approved by the Engineer. This approval shall not be deemed to constitute acceptance of the sub-base course for full payment purposes.

B. Sampling and testing shall conform to the relevant requirements of part 1 of the Specification, Section 4-6 Samples and Approvals.

C. Compaction shall be tested in accordance with AASHTO T 191 or AASHTO T 205. If there is a delay between the construction of any layer and the following layer, if necessary and required by the Engineer the compaction of the lower layer shall be retested to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

Table 3.2.1: Required Tests and Minimum Repetition for Sub-Base Course Material

Control on Site after Laying and Compaction	
Required Tests	**Frequency**
1. Proctor 2. Gradation of Materials 3. Plasticity Index 4. C.B.R 5. Abrasion 6. Sand equivalent 7. Clay lumps & friable particles 8. Field Density	• Test for every 500 m for each layer and lane width, when material source or process changes and when otherwise instructed by the Engineer,
9. Thickness	• Test for every 1000 m^2 and for every layer

3.02.08 MEASUREMENT

A. Granular Sub-Base Course shall be measured by the cubic metre of granular material furnished, screened, crushed if necessary, mixed with water, placed, spread, compacted and finished, completed, and accepted. Measurements shall be of the volumes computed from the cross sections shown on the Drawings and of the field measurements of area and compacted depth of each Trial Section.

B. Rates for Granular Sub-Base Course in Temporary Diversions shall also include for removal and disposal of the sub-base material and reinstatement of the area of the temporary diversion, to the satisfaction of the Engineer, on completion of use.

C. No measurement shall be made for direct payment of over-depth or over-wide construction, regardless of the Engineer's permission for it to remain in place.

SECTION 3.03 AGGREGATE BASE COURSE

3.03.01 SCOPE

The work covered in this Section consists of furnishing crushed aggregate base course material of the required class, mixing, spreading on a prepared sub-base course, compacting and finishing, as and where shown on the Drawings.

3.03.02 MATERIALS

All materials shall conform to the relevant requirements of Section 3.01 - Materials for Sub-Base and Base Courses, in respect of crushed aggregate for base course construction and the particular requirements for base courses detailed on the Drawings.

3.03.02 SURFACE PREPARATION

A. Where a sub-base course is present, it shall have previously been constructed in accordance with the requirements of Section 3.02: Granular Sub-Base Course and properly maintained and kept well drained thereafter.

B. The sub-base surface shall be inspected and approved prior to commencement of base construction. Holes, depressions and other irregularities shall be made good as directed by the Engineer and the sub-base recompacted as necessary and finished ready to receive the base course.

C. Where a sub-base course has been omitted in the Drawings and the aggregate base course is placed directly on completed sub-grade, preparation of the sub-grade surface shall be as specified in Section 3.02 - Granular Sub-Base Course.

3.03.03 EQUIPMENT

Equipment used to handle, place, spread, water, compact and finish base course shall conform to the requirements of Part 1 - Section 4-4: Contractor's Plant and Equipment of the Specification and with the Contractor's approved work programme.

3.03.04 CONSTRUCTION OF TRIAL SECTIONS

A. If the Engineer deems it necessary the Contractor shall lay and compact trial sections of varying thickness of base. Each trial section shall be 2 lanes wide by 50 m long, at locations agreed by the Engineer on or close to the Site. Each trial section shall be laid using the same materials, mix proportions, mixing, spreading and compaction equipment, and construction procedures, proposed for use in the Works.

B. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth measurements that will result in the specified compacted layer depths, the field moisture content for compaction and the relationship between the number of compaction passes and the resulting density of the base course material.

3.03.05 CONSTRUCTION

A. Stockpiling of Aggregate Materials

Stockpiling procedures shall conform to the relevant requirements of Section 3.01 - Materials for Sub-base and Base Courses.

B. Mixing and Spreading

B.1 All components of base course material may be premixed with water, in a pugmill mixing plant or on site. The amount of water added, as determined, shall be such that the material will be uniform and within the specified moisture content range at the time of compaction. The Engineer shall consider other methods of mixing provided such method(s) do not reduce the standard of work. The Contractor shall demonstrate, in the presence of the Engineer, his ability to attain the requirement given in this Specification.

B.2 The premixed material shall be placed on the sub-base in a uniform layer or layers not exceeding 250 mm in thickness before compaction. Where the required uncompacted thickness is greater than 250 mm but less than 500 mm, the material shall be placed in layers of equal thickness.

B.3 Compaction of sub-base in layers of up to 350 mm after compaction shall be permitted if heavy duty vibratory compaction equipment is used and compaction tests with appropriate testing equipment indicate that the specified compaction standard will be attained and uniform throughout the thickness of the layer.

B.4 The base course material shall be placed to the required width using a self-propelled spreader or motor grader and shall be delivered such that it is ready for compaction without further shaping.

B.5 The material shall not be handled in such a way as to cause segregation. If the spreader causes segregation in the material or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the spreader operation, the use of such a spreader shall forthwith be discontinued and it shall be replaced by a spreader capable of carrying out this work in a satisfactory manner.

B.6 All segregated material shall be removed and replaced with well-graded material. Skin patching shall not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances shall be permitted during the compaction process.

B.7 Hauling or placement of material shall not be permitted when, in the judgment of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of the sub-base or sub-grade or cause contamination of the base material.

C. Compaction

C.1 The Contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If the Contractor delays placing of succeeding layers of material to the extent that additional water is required to prevent ravelling or excessive drying, the application of such water shall be carried out using a method approved by the Engineer and at the Contractor's expense.

C.2 The base course material shall be compacted by means of suitable compaction equipment, progressing gradually from the outside towards the centre, with each succeeding pass uniformly overlapping the previous pass.

C.3 Rolling shall continue until the entire thickness of each base layer is thoroughly and uniformly compacted to 100% AASHTO T 180 (Method D) maximum density. Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient blading to ensure a smooth surface, free from ruts or ridges and having the proper shape. When additional water is required, it shall be applied by a method approved by the Engineer.

C.4 Any areas inaccessible to normal compaction equipment shall be compacted by use of portable mechanical tampers until the required standard of compaction is achieved.

C.5 Each layer shall be completely compacted and approved prior to delivery of materials for the following layer.

C.6 Prior to placing a following layer, the surface shall be made sufficiently moist, to the satisfaction of the Engineer, to ensure an effective bond between the layers.

C.7 The edges and edge slopes of the base course shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

C.8 Material which has dried out prior to final compaction or which has dried and de-compacted subsequent to final compaction shall be watered and recompacted using approved equipment and procedures. If the Contractor is unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerances, the Contractor shall scarify the material in the upper layer and reconstruct the base course on a re-approved sub-base surface to the satisfaction of the Engineer.

D. Tolerances

D.1 The fully compacted and completed base course shall conform to the lines, grades and cross sections as shown on the Drawings.

D.2 The elevations of the finished base course shall be checked by the Contractor in the presence of the Engineer at intervals of 20 metres on straight lines and of 10 metres on curves and at intermediate points as directed.

D.3 The tolerances on elevations of the finished surface shall not exceed + 10 mm or -15 mm.

D.4 When the finished surface is tested with a 4 metre long straightedge, placed parallel to or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed 12 mm.

D.5 All areas which exceed the specified tolerances shall be corrected by removing defective sections of base course and reconstructing them or by scarifying and adding new material and re-compacting and finishing to the specified standard.

E. Maintenance of Completed Base

Following completion and acceptance of the base course it shall be maintained by the Contractor at his own expense. The surface shall be broomed rolled and otherwise maintained, keeping it free from ravelling and other defects until the following course is placed. Water shall be applied at such times and in such quantities as directed by the Engineer.

3.03.06 TESTING

A. Base course material shall be tested in accordance with Table 3.3.1 after in-situ compaction and if satisfactory shall be approved for use by the Engineer. This approval shall not be deemed to constitute acceptance of the base course for full payment purposes.

B. Sampling and testing shall conform to the relevant requirements of specifications Part 1 - Section 4-6 Samples and Approvals.

C. Compaction shall be tested in accordance with AASHTO T 191, AASHTO T 205 as specified on the Drawings or as agreed by the Engineer. If there is a significant delay between the construction of any layer and the following layer, the Engineer may require the compaction of the lower layer to be retested to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

Table 3.3.1: Required Tests and Minimum Repetition for As- Laid Base Course Material

Control on Site after Laying and Compaction	
Required Tests	**Frequency**
1. Proctor 2. Gradation of Materials 3. Plasticity Index 4. C.B.R 5. Abrasion 6. Sand equivalent 7. Clay lumps & friable particles 8. Field Density	• Test for every 500 m for each layer and lane width and when material source or properties changed
9. Thickness	• Test for every 1000 m^2 and for every layer

3.03.07 MEASUREMENT

A. Aggregate Base Course shall be measured by the cubic metre of aggregate materials furnished, crushed, screened, mixed with water, placed, spread, compacted and finished, completed, and accepted. Measurements shall be of volumes computed from the cross sections shown on the Drawings and of the field measurements of the area and compacted depth for each Trial Section.

B. Rates for Aggregate Base Course in Temporary Diversions shall also include for removal and disposal of the sub-base material and reinstatement of the area of the temporary diversion, to the satisfaction of the Engineer, on completion of use.

C. No measurement shall be made for direct payment of overdepth construction, regardless of the Engineer's permission for it to remain in place.

SECTION 4: BITUMINOUS CONSTRUCTION

SECTION 4: BITUMINOUS CONSTRUCTION

SECTION 4.01 MATERIALS FOR BITUMINOUS CONSTRUCTION

4.01.1 SCOPE

A. Materials specified for use in the construction of the various bituminous pavement courses include the following:

- Coarse and fine mineral aggregates and filler.
- Bitumen products including penetration graded bitumens, cutback bitumens, emulsified bitumens and modified bitumens for use in bituminous courses and surface treatments.

B. All material sources and the quality of materials proposed for use in the Works shall be approved prior to procuring or processing material from such sources. Inspection, sampling, testing and retesting as necessary, shall be at the Contractor's expense as specified hereunder for specific materials.

C. Storage and handling of all materials shall conform to the relevant requirements of Part 1 of Specification Section 4.3: Materials. Materials shall be stored on hard, clean surfaces.

4.01.2 AGGREGATE MATERIALS GENERAL

A. Sources and Production

A.1 The Contractor shall have satisfied himself as to the location, suitability and quantity of materials available; extent of work necessary to obtain the material available; the work required to open the quarry and to crush, screen and wash (if necessary) the materials; and the length of haul to the Site prior to the start of Works.

A.2 Prior to starting quarry operations, the Contractor shall obtain written permission for extraction from the Authorities and/or owners concerned.

A.3 Crushing and screening plant shall not be put into operation prior to the Engineer’s written approval. If after being put into operation any plant fails to perform as intended the Contractor shall either rectify the defects in the existing plant to the satisfaction of the Engineer or shall provide alternative approved plant.

A.4 Approval of the crushing and screening plant and other equipment shall not relieve the Contractor of his responsibilities in respect of producing aggregates which conform to the Specifications and in the quantities required for the timely completion of the Works.

B. Stockpiling

B.1 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 stockpile areas shall be adequately drained at all times.

B.2 Stockpiling procedures shall not result in degradation or segregation of the stockpiled material or the introduction of foreign materials into the stockpile. Heights of aggregate stockpiles shall not exceed 5 metres.

B.3 Topsoil shall be stripped from the stockpile areas prior to use and stored on site in heaps no higher than 1.5 metres and reinstated on completion of the works.

C. Sampling and Testing

C.1 Sampling and testing procedures shall conform to the relevant requirements of Part 1 – Section 4.6: Samples and Approvals and to the following requirements.

C.2 The Contractor shall submit to the Engineer for approval at least 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.

C.3 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 into the Works, prior to starting quarry operations. The representative samples shall be taken by the Contractor in the presence of the Engineer.

C.4 Tests performed by the Contractor shall be utilized in assessing the location, extent of deposits and quantities of materials conforming to the Specification when properly processed. Any special tests that may be required by the Engineer shall be carried out by the Contractor either in his own laboratory or in an outside laboratory approved by the Engineer. All testing as carried out by the Contractor shall not obviate the need for further testing by the Engineer. Approval of specific sources of materials shall not be construed as final approval and acceptance of materials from such sources.

C.5 Processed materials shall be tested and approved before being stockpiled on Site or incorporated in the Works and shall be inspected and tested at any time by the Engineer during preparation, storage and use. Questionable materials awaiting testing and approval shall not be unloaded and mixed with materials previously approved. If the grading and quality of any materials delivered to the Site do not conform to the grading and quality of the established control samples, the Engineer shall reject such materials.

C.6 Samples shall satisfy all specified test requirements. The Contractor shall allow the Engineer to inspect any and all materials used or to be used at any time during or after preparation or while being used during construction of the Works. Unsatisfactory materials, whether in place or not, shall be removed promptly from the Site. The Contractor shall furnish all necessary materials, labour, tools, equipment and transport required by the Engineer for such inspections.

4.01.3 AGGREGATES FOR BITUMINOUS PAVING MIXES

A. Aggregates for use in bituminous base course, levelling course, macadam and cold mix courses shall consist of crushed rock or crushed gravel. Aggregates for use in wearing courses shall consist of crushed rock.

B. Coarse aggregate shall be the fraction of crushed aggregate material retained on a 4.75 mm (No. 4) sieve. Fine aggregate shall be the fraction of crushed aggregate material passing a 4.75 mm (No. 4) sieve. Mineral filler shall be added when the combined grading of coarse and fine aggregates is deficient in material passing a 0.075 mm (No. 200) sieve.

C. The material from hot bins passing the number 40 sieve (0.425mm) when tested in accordance with AASHTO T90 shall be non-plastic. In addition the material from cold bins shall not have a PI larger than 4.

D. Aggregates shall not contain more than 1% gypsum and the coarse fraction of the aggregate shall not contain more than 5% chert.

E. Aggregates shall be of uniform quality, free from decomposed stone, organic matter, and shale.

F. The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T112.

G. Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on a 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.

H. The flakiness index and the elongation index tests shall be conducted in accordance with BS EN 933-3:1997 with the following maximum limits:

	Wearing Course	**Binder & Bituminous Base Courses**
Flakiness Index (FI).	20	35
Shape Index (SI).	25	30

I. Aggregates shall be washed to remove any clay lumps, organic matter, adherent dust, clay film or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.

J. Mineral filler shall consist of finely divided mineral matter such as limestone dust, hydrated lime, other non-plastic mineral filler free from clay and organic impurities and Portland cement, conforming to AASHTO M 17.

K. Combined coarse and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T 27 and T11, shall conform to the gradings shown in Table 4.1.1.

TABLE 4.1.1: GRADING OF AGGREGATES FOR BITUMINOUS MIXES

SIEVE SIZE	**PER CENT PASSING**	
	Base Course	**Wearing Course**
1" (25.0 mm)	100	.....

3/4" (19.0 mm)	65-100	100
3/8" (9.5 mm)	47-72	56-80
No. 4 (4.75 mm)	30-56	35-56
No. 10 (2.00 mm)	19-36	22-36
No. 40 (0.425 mm)	8-20	8-20
No.200 (0.075 mm)	2-8	2-8

L. The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96, shall not exceed 35%.

M. When tested for soundness in accordance with AASHTO T104 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 10% in the case of the sodium sulphate test and 12% in the case of the magnesium sulphate test.

N. When testing for resistance to stripping in accordance with AASHTO T-182 at least 95% coated particles shall remain.

4.01.4 AGGREGATES FOR SEAL COATS

A. Cover aggregates for bituminous seal coats shall consist of screenings of crushed stone. Aggregate for slurry seals shall consist of crushed stone fines or natural sand blended with not less than 50% crushed stone fines. For heavy duty applications slurry aggregate shall consist of 100% crushed fines. The suitability of sources of crushed stone fines for use in slurry seal shall be demonstrated to the Engineer for approval prior to use.

B. Aggregates shall not contain more than 1% crystalline or amorphous gypsum (expressed as SO_3) and shall not contain more than 5% chert.

C. Aggregate particles shall be clean hard durable and sound. For particles retained on 4.75 mm (No. 4) sieve at least 90% by weight shall have 2 or more fractured faces and 100% by weight shall have one or more fractured faces.

D. Flakiness and Elongation Indices shall be tested in accordance with BS EN 933-3:1997 and shall not exceed 25 %. The percentage by weight of clay lumps & friable particles as determined by AASHTO T 112 shall not exceed 3%. Lightweight aggregate of specific gravity of 2 or less shall not exceed 3 % as determined by AASHTO T 113.

E. Aggregates shall be washed or processed by any alternative approval method 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.

F. Cover aggregates and aggregate for slurry seals shall be tested in accordance with AASHTO T 27 and T11 and shall conform to the gradations given in Table 4.1.2.

Table 4.1.2: Gradation of Aggregates for Seal Coats

Sieve Designation (Square openings)	1st Application Grading B	2nd Application Grading C	Slurry Aggregate
25.0 mm (1 in)	100		
19.0 mm (3/4 in)	90 - 100		
12.5 mm (1/2 in)	20 - 55	100	
9.50 mm (3/8 in)	0 -15	58 - 100	100
4.75 mm (No. 4)	0 - 5	10 -30	90 - 100
2.36 mm (No. 8)	-	0 -10	65 -90
1.18 mm (No. 16)	-	0 -5	45 -70
0.60 mm (No. 30)	-	-	30 - 50
0.30 mm (No. 50)	-	-	18 -30
0.15 mm (No. 100)	-	-	10 -20
0.07 mm (No. 200)	0 - 0.5	0 - 0.5	5 -15

G. The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Test), shall not exceed 30 %.

H. When tested for soundness in accordance with AASHTO T 104, the aggregates shall not show signs of disintegration and the loss by weight shall not exceed 10% in the case of the sodium sulphate test or 12% in the case of the magnesium sulphate test.

I. When tested for resistance to stripping in accordance with AASHTO T 182, at least 95% of the aggregate surface area shall remain coated with a bitumen film.

4.01.5 BITUMEN

A. Type Certification and Grade

A.1 The Contractor shall furnish the vendor's certified test reports for each load of bitumen delivered to the site. Each report shall be delivered to and approved by the Engineer before the material in the load may be used. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance.

A.2 The grade of bitumen may be changed by the Engineer by one grade either side of the specified grade at no extra cost to the Employer. When more than one type or grade is specified under any item, the Engineer shall select the type and grade to be used in the Works.

B. Transporting Bitumen

B.1 All transporting of bitumen shall be by conveyances that are free from contamination. Tank cars or tank trucks used for transporting bitumen shall be carefully

inspected, drained and cleaned before loading to prevent contamination of the bitumen from residues of previous loads. Bitumen may also be delivered and transported in metal drums.

B.2 Tank trucks or trailers used to transport bitumen shall be equipped with a suitable sampling device which shall be built into the tank, recirculating or discharge line so that a sample can be drawn during circulation or discharge.

C. Storage of Bitumen

C.1 The Contractor shall provide an adequate storage facility for bitumen at the site of the mixing plant. This facility shall be clean, stable and provided with cover and shelter from excessive temperatures.

C.2 No open fires or smoking shall be permitted in or around the storage facility.

C.3 The storage capacity shall be sufficient to maintain a uniform operation while allowing for delayed shipments and time for testing. Different batches of bitumen shall be separated to allow for easy identification.

C.4 If the bitumen is delivered to the site in metal drums they shall be inspected on arrival at Site for perforations, rusting, melting and other defects that would directly cause pollution or chemical changes to the bitumen. Any drums showing any of these defects shall be rejected by the Engineer.

C.5 The stored bitumen products should be protected from temperatures that exceed the range of $-5^{o}C$ to $+60^{o}C$.

D. Heating of Bitumen

D.1 Heating equipment shall be of a type approved by the Engineer. Any method of agitation or heating that introduces free steam or moisture into the bitumen shall not be approved. During the process of manufacture, conveyance, storage and construction, all bitumen shall not be heated to temperatures more than $10^{o}C$ above the maximum application temperature specified nor above $170\ ^{o}C$, whichever is the lower. Materials heated in excess of these temperatures shall be rejected by the Engineer and not be used in the Works.

D.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. The circulation system shall be of adequate size to ensure proper and continuous circulation of the bitumen during the entire operating period. Steam, oil jacketing or other insulation shall be provided for maintaining the required temperature of bitumen, weigh buckets, spray bars and other containers.

D.3 Thermometers of approved types and adequate range (calibrated in $1^{o}C$ 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.

D.4 Where storage tanks are required, their capacity shall be sufficient for at least one day's production.

D.5 Bitumen materials wasted through careless handling or rendered unsuitable for use by overheating shall not be used in the Works.

E. Sampling and Testing

E.1 Procedures for sampling of bituminous materials shall conform to AASHTO T 40.

E.2 General requirements and procedures for sampling and testing of the various types of bitumen shall conform to Part 1–Section 4.6: Samples and Approvals.

4.01.6 BITUMEN PRODUCTS

A. Penetration Graded Bitumen

A.1 Penetration graded bitumen shall conform generally to the requirements of AASHTO M 20 as given in Table 4.1.3.

TABLE 4.1.3: PROPERTIES OF PENETRATION GRADE BITUMEN

	Penetration Grade					
	40 -50		60 - 70		85 - 100	
	Min	Max	Min	Max	Min	Max
Ductility at 25°C (cm)	100	-	100	-	100	-
Penetration at 25°C (0.1 mm)	40	50	60	70	85	100
Softening Point (° C)	50	58	48	56	45.8	48
Specific Gravity at 25°C	1.01	1.06	1.01	1.06	1.0	-
Loss on heating 163°C	-	0.8	-	0.8	-	1.0
Penetration of residue % of original	58	-	54	-	50	-
Solubility in Trichloroethylene (% wt)	99	-	99	-	99	-
Ash content % wt	-	1.0	-	1.0	-	1.0
Flashpoint (Cleveland Open Cup.) (°C)	250	-	250	-	225	-

A.2 Sampling and testing shall be in accordance with the AASHTO standard method listed in AASHTO M 20.

A.3 The penetration bitumen application temperature range shall be determined to ensure that the appropriate viscosity range for each application is achieved. If the viscosity curves are not available the values given in table 4.1.4 shall be used.

TABLE 4.1.4: BITUMEN APPLICATION TEMPERATURE RANGE

Bitumen Grade	40/50	60/70	80/100

Application Temperature °C	150-170	145-165	140-160

B. Bitumen Modifier

B.1 Whenever specified, an approved modifier shall be incorporated in all penetration graded bitumens immediately prior to the time of use unless otherwise shown on the Drawings. The modifier shall serve to polymerize the bitumen by converting the benzylic carbon groups into ketones.

B.2 The modified bitumen shall demonstrate significantly reduced temperature susceptibility and/or improved adhesive qualities. The workability of the modified bitumen shall be unchanged from that of unmodified bitumen.

B.3 The mixing and preparation of modified bitumen shall be carried out in accordance with the manufacturers' instructions, and with the approval of the Engineer.

C. Rapid-Curing (RC) Cutback Bitumen

C.1 RC cutback bitumen shall conform to the requirements of AASHTO M 81, grades RC-70, RC-250, RC-800, and RC-3000 with properties as listed in Table 4.1.5.

C.2 Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 81.

C.3 RC cutback bitumen spraying temperature ranges shall be as follows:

RC Cutback Bitumen Grade	**Spraying Temp ^{o}C**
RC - 70	40 - 75
RC - 250	65 - 105
RC - 800	90 - 115
RC - 3000	105 - 135

D. Medium-Cured (MC) Cutback Bitumen

D.1 MC cutback bitumen shall conform to the requirements of AASHTO M 82, grades MC-30, MC-70, MC-250, MC-800 and MC-3000 with properties as listed in Table 4.1.6.

D.2 Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 82.

D.3 MC cutback bitumen spraying temperature ranges shall be as follows:

MC Cutback Bitumen Grade	**Spraying Temp ^{o}C**
MC - 30	21 - 63
MC - 70	45 - 80

MC - 250	70 - 110
MC - 800	95 - 125
MC - 3000	110 - 145

E. Slow-Curing (SC) Cutback Bitumen

E.1 SC cutback bitumen shall conform to the requirements of ASTM D 2026 grades SC-70, SC-250, SC-800, and SC-3000 with properties as listed in Table 4.1.7.

E.2 Sampling and testing shall be in accordance with the appropriate ASTM standard methods.

E.3 SC cutback bitumen spraying temperature ranges shall be as follows:

SC Cutback Bitumen Grade	**Spraying Temp ^{o}C**
SC – 70	45 - 80
SC -250	70 - 110
SC - 800	95 - 125
SC - 3000	110 - 145

F. Emulsified Bitumens

F.1 Selection and use of emulsified bitumens shall generally be in accordance with the recommendations in AASHTO R 5, subject to the following requirements.

F.2 Emulsified bitumens which have been subjected to freezing temperature while in storage shall be retested and acceptance or rejection of the material shall be based on the results of the retest.

F.3 The manufacturer shall furnish samples of the base bitumen used in the emulsion.

F.4 When samples of undiluted emulsion are not readily available for test purposes, tests shall be made on the diluted emulsion and the respective specifications modified to reflect the changes in properties resulting from dilution of the bitumen.

F.5 All emulsified bitumens shall adhere firmly to the surface of the mineral aggregate or the highway surface as appropriate. Failure of the emulsified bitumen to perform satisfactorily on the job shall be deemed cause for its rejection regardless of satisfactory laboratory test results.

G. Anionic Emulsified Bitumen

G.1 Anionic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 140, for Types SS-1 and SS-1h and as listed in Table 4.1.8.

G.2 Sampling and testing shall be in accordance with AASHTO T 59.

G.3 Emulsified bitumen spraying temperature ranges shall be determined to ensure that appropriate viscosities for each application are achieved. If the viscosity curves are not available values shall be 25-65^{o}C, except for Grade RS-2 where the range shall be 50-75^{o}C. The temperature range for pugmill mixing for medium and slow setting types shall be 15-65^{o}C.

H. Cationic Emulsified Bitumen

H.1 Cationic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 208, for Types CSS-1 and as listed in Table 4.1.9.

H.2 Sampling and testing shall be in accordance with AASHTO T 59.

H.3 The emulsified bitumen spraying temperature range shall be so that appropriate viscosity for each application is achieved. If viscosity curves are not available these values, generally considered as guidance shall be in the range of 25-65 ^{o}C (except for Grade CRS-2 where the range shall be 50-75 ^{o}C). The temperature range for pugmill mixing for medium and slow setting types shall be 15-65 ^{o}C.

TABLE 4.1.5: PROPERTIES OF R.C. CUTBACK BITUMEN

	RC-70		**RC-250**		**RC-800**		**RC-3000**	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Kinematic Viscosity at 60^{o}C centistokes	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open-cup) ^{o}C	-	-	27	-	27	-	27	-
Water, %	-	0.2	-	0.2	-	0.2	-	0.2
Distillation Test:								
Distillate, % by volume of total distillate to 360^{o}C								
- to 190^{o}C	10	-	-	-	-	-	-	-
- to 225^{o}C	50		35	-	15	-	-	-
- to 260^{o}C	70		60	-	45	-	25	-
- to 315^{o}C	85		80	-	75	-	70	-
Residue from distillation to 360^{o}C volume percentage of sample by difference	55	-	65	-	75	-	80	-
Volume percentage of sample by difference	600	2400	600	2400	600	2400	600	2400
Tests on residue from distillation Absolute viscosity at 60^{o}C poises	100	-	100	-	100	-	100	-
Ductility, 5 cm/min. at 25 ^{o}C cm	99	-	99	-	99	-	99	-
Solubility in Trichloroethylene, %								
Spot Test with:								

Standard naphtha	Negative for all grades
Naphtha-xylene solvent, - % xylene	Negative for all grades
Heptane-xylene solvent, - % xylene	Negative for all grades

TABLE 4.1.6: PROPERTIES OF M.C. CUTBACK BITUMEN

	MC-30		MC-70		MC-250		MC-800		MC-3000	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Kinematic Viscosity at 60°C centistokes	30	60	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open- cup) °C	38	-	38	-	66	-	66	-	66	-
Water, %	-	0.2	-	0.2	-	0.2	-	0.2	-	0.2
Distillation Test:										
Distillate, % by volume of total distillate to 360°C										
- to 225°C	-	25	0	20	0	10	-	-	-	-
- to 260°C	40	70	20	60	15	55	0	35	0	15
- to 315°C	75	93	65	90	60	87	45	80	15	75
Residue from distillation to 360°C volume percentage of sample by difference	50	-	55	-	67	-	75	-	80	-
Tests on residue from distillation Absolute viscosity at 60°C poises	300	1200	300	1200	300	1200	300	1200	300	1200
Ductility, 5 cm/min. at 25 °C cm	100	-	100	-	100	-	100	-	100	-
Solubility in Trichloroethylene, %	99	-	99	-	99	-	99	-	99	-
Spot Test with:										
Standard naphtha	Negative for all grades									
Naphtha-xylene solvent, - % xylene	Negative for all grades									
Heptane-xylene solvent, - % xylene	Negative for all grades									

TABLE 4.1.7: PROPERTIES OF S.C. CUTBACK BITUMEN

	SC - 70		SC - 250		SC - 800		SC - 3000	
	Min	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Kinematic Viscosity at 60 °C centistokes	70	140	250	500	800	1600	3000	6000
Flash Point (Cleveland open-cup) °C	66	-	79	-	93	-	107	-
Distillation test:								
Total distillate to 360°C, volume %	10	30	4	20	2	12	-	5
Solubility in trichloroethylene %	99.	-	99.	-	99.	-	99.	-
Kinematic viscosity on distillation residue at 60°C, St	4	70	8	100	70	160	40	350
Asphalt residue:								
Residue of 100 penetration %	50	-	60	-	70	-	80	-
Ductility of 100 penetration	100	-	100	-	100	-	100	-
Residue at 25°C, cm Water, %	-	0.5	-	0.5	-	0.5	-	0.5

TABLE 4.1.8: PROPERTIES OF ANIONIC EMULSIFIED BITUMEN (SLOW SETTING)

	SS-1		SS-1h	
	Min.	**Max.**	**Min.**	**Max.**
Test on emulsions:				
Viscosity, Saybolt Furol at 25° C,s	20	100	20	100
Viscosity, Saybolt Furol at 50° C,s	-	-	-	-
Storage stability test, 24-h, %	-	1	-	1
Cement mixing test, %	-	2.0	-	2.0
Sieve test, %	-	0.1	-	0.1
Residue by distillation, %	57	-	57	-
Tests on residue from distillation test:				
Penetration, 25°C, 100g, 5 s	100	200	40	90
Ductibility, 25°C 5 cm/min. cm	40	-	40	-
Solubility in trichloroethylene %	97.5	-	97.5	-

TABLE 4.1.9: PROTECTION OF CATIONIC EMULSIFIED BITUMEN

	Slow-Setting CSS-1	
	Min.	**Max.**
Tests on emulsions:		
Viscosity, Saybolt Furol at 25°C, s	200	100
Storage stability test, 24-h, %	1	
Particle charge test	Positive	
Sieve test, %		
Cement mixing test, %		0.10
Distillation:		2.0
Residue, %	57	
Tests on residue from distillation test:		
Penetration, 25°C, 100 g, 5 s	100	250
Ductibility, 25°C, 5 cm/min, cm	40	
Solubility in trichloroethylene %	97.5	

4.01.7 MEASUREMENT

Items listed in this Section shall be measured as prescribed in the appropriate sections of these Specifications.

SECTION 4.02 BITUMINOUS PRIME AND TACK COATS

4.02.1 SCOPE

The work covered in this section consists of furnishing and applying MC cutback bitumen prime coat to a previously constructed subgrade, aggregate base course, highway shoulders, or concrete pavement; and furnishing and applying RC cutback bitumen or emulsified bitumen as a tack coat to a previously constructed bituminous base or wearing surface to provide a bond for a superimposed bituminous course as and where shown on the Drawings.

4.02.2 MATERIALS

A. Medium-Curing Cutback Bitumen

MC cutback bitumen (for prime coats) shall be as recommended by ASTM D2399-83. MC 70 shall be used unless otherwise specified.

B. Rapid-Curing Cutback Bitumen

RC cutback bitumen (for tack coats) shall be Grades RC-70 or RC-250 as appropriate and as specified in Section 4.01 - Materials for Bituminous Construction or as specified in the Drawings.

C. Slow-Curing Emulsified Bitumen

Slow-setting emulsified bitumen (for tack coats) shall be slow-setting Grades SS-1, SS-1h, CSS-1, or CSS-1h, as appropriate and as specified in Section 4.01 - Materials for Bituminous Construction or as specified in the Drawings..

4.02.3 EQUIPMENT

Equipment used for diluting emulsified bitumen, heating cutback bitumen, spraying cutback and emulsified bitumen and for the application of blotting material to prime coats shall conform to the requirements of Part 1 of Specification Section 4-4 - Contractor's Plant and Equipment.

4.02.4 CONSTRUCTION OF TRIAL SECTIONS

A. The Engineer shall, if necessary, instruct 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 Engineer. Each trial section shall be 2 lanes wide by 50 metres long, at approved locations on or close to the Site.

B. Each trial section shall be constructed using the same materials, mixing and spraying equipment and construction procedures proposed for use in the Works.

C. 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.

D. The Contractor shall not proceed with any site coat applications until the methods and procedures established in the trials have been approved by the Engineer.

4.02.5 APPLICATION PROCEDURES

A. General

A.1 All equipment used for surface cleaning, heating bitumen and application of prime and tack coats shall be suitable for the purposes intended and shall be approved by the Engineer before use.

A.2 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. Surfaces shall be approved before applying any bitumen material.

A.3 Prime coats and tack coats shall be applied only when the surface to be treated is sufficiently dry for tack coats and sufficiently moist for prime coats and when the ambient temperature is above 10^{o}C for the application of tack coat and 15^{o}C for the application of prime coat. Prime and tack coats shall not be applied during fog, rain, strong winds, generally dusty conditions or dust storms.

A.4 The surfaces of all structures, kerbs, gutters and other highway appurtenances shall be protected to prevent them from being splattered or stained with bitumen or damaged during equipment operation. The Contractor shall be responsible for making good any such staining or damage to the satisfaction of the Engineer.

A.5 Traffic shall not be permitted on surfaces after they have been cleaned and prepared for prime or tack coat application.

A.6 If there are undue delays in applying prime or tack coats or subsequent paving thereafter, the surface tolerances and compaction of the granular course shall be reverified, deficient areas corrected and or replaced and prime or tack coats reapplied in accordance with the Engineer’s instructions and at the Contractor's expense.

A.7 The Contractor shall maintain prime coats and tack coats intact until they are covered by the subsequent pavement course. Any area where the coats have been damaged shall be cleaned of all loose material, surface defects repaired and the coat re-applied at the Contractor's expense. Traffic control measures shall conform to the relevant requirements of Section 6.07 - Maintenance of Traffic and Detours.

B. Prime Coat Application

B.1 If required by the Engineer, when the surface is an untreated subgrade or a granular surface, the cleaned surface shall be given a light application of water and allowed to dry to the condition deemed appropriate by the Engineer before the bituminous material is applied.

B.2 Heating of MC cutback bitumen and its temperature at the time of application shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

B.3 Areas to be primed shall be as shown on the Drawings and shall include 200 mm widths outside the edges of the pavement line, the top of embankment slopes to the pavement lines and between kerbs or gutter edges at bridges and viaducts.

B.4 Application rates for prime coat shall be determined by the Engineer from the trial sections and shall be generally within the following ranges:

Range of Application Rates for Prime Coat

Type of Surface	**Litres/ m^2**
Untreated subgrade surfaces, shoulders base course:	0.75 - 2.0
Bridge wearing surfaces, concrete pavements:	0.1 - 0.4
Other surfaces:	As determined from field tests or trials

B.5 The Engineer may order additional trial sections and/or alter the previously established rates of application during progress of the Works.

B.6 Prime coat shall be applied using pressure distributors operated by skilled workmen. The spray nozzles and spray bar shall be adjusted and frequently checked so that a uniform distribution is ensured. Spraying shall cease immediately if any nozzle ceases to spray and corrective measures taken before spraying is resumed.

B.7 Hand spraying shall be used only for priming small patches or inaccessible areas that cannot be primed by the normal operation of the pressure distributor.

B.8 Application of prime between separate areas of priming shall not be excessive. Any excess prime coat shall be removed from the surface and any skipped areas or recognized deficiencies shall be corrected using hand sprays.

B.9 When required by the Engineer, a light covering of blotting material shall be applied to the prime coat 48 hours after spraying and when it has not dried sufficiently to withstand damage by traffic. The blotting material shall be a smooth fine sand or other material approved by the Engineer.

B.10 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 Engineer.

C. Tack Coat Application

C.1 Tack coat application shall be as shown on the Drawings and on clean dry surfaces and the application rate shall be as instructed by the Engineer. Emulsified bitumen shall be diluted and thoroughly mixed with an equal amount of water before application.

C.2 Heating of RC cutback bitumen and its temperature at the time of application shall conform to the relevant requirements of Section 4.03: Bituminous Courses. Where slow-curing emulsified bitumen (SS or CSS Type) is used for tack coat, it shall not require heating except in temperatures below 20^{o}C.

C.3 The rate of application shall be approved by the Engineer between 0.1 and 0.6 kg. /sq m. depending on whether RC cutback or emulsified bitumen is used and on the surface condition of the bituminous course on which the tack coat is to be sprayed. The Engineer shall alter the previously established rates of application during progress of the Works, if he deems it necessary.

C.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 applications shall not proceed so far in advance of the following course that it dries out completely.

C.5 Spraying procedures shall be as specified for prime coat application.

C.6 Blotting material shall not be applied to tack coats.

4.02.6 MEASUREMENT

A. Bituminous Prime Coat shall be measured by the square metre of the areas primed at the appropriate rate specified by the Engineer.

B. Bituminous Prime Coat for Temporary Diversions shall be measured separately as shown in the Bill of Quantities.

C. Bituminous Tack Coat shall be measured by the square metre of the areas applied at the appropriate rate specified by the Engineer.

D. Surface preparation, protective measures to avoid staining or damage to appurtenances, blotting of prime coats when required and cleaning stains and repairing damage caused by equipment, etc shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which shall be deemed to be included in the Contract prices for the Pay Items.

SECTION 4.03 BITUMINOUS COURSES

4.03.1 SCOPE

A. The work covered in this Section consists of the general requirements for furnishing materials, mixing at a central mixing plant, spreading and compacting the various bituminous concrete and other bituminous mixes including the installation of reinforcing fabric when specified, all as and where shown on the Drawings.

B. Requirements with particular application to bituminous base courses, wearing courses, levelling courses, macadam courses, cold mix courses and recycled bituminous base course, are specified in the respective sections relating to such courses.

4.03.2 MATERIALS

A. Bituminous mixes shall comprise of coarse and fine mineral aggregate, mineral or cement filler and penetration grade bitumen with mix additives if specified. Bitumen shall either be cutback or emulsified as appropriate to the type of bituminous course to be constructed.

B. All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

4.03.3 JOB MIXES AND PROJECT MIXES

A. At least 30 days prior to the date the Contractor intends to begin production at the mixing plant and after receiving approval of the aggregates and delivery to the Site of the bitumen specified, the Contractor shall submit for the Engineer's approval his proposed Job Mix Formula.

B. The Job Mix Formula shall stipulate a single combined grading of all aggregate and filler materials showing the specific percentages by weight passing each sieve size and of each material to be used in the total mix.

C. The Job Mix Formula shall be established by the Contractor, under the supervision of the Engineer, in the field laboratory. Mix design procedures shall conform to the Marshall method of mix design and relevant procedures contained in Asphalt Institute Manual MS-2, Sixth Edition. All trial mixes shall be prepared and tested by the Contractor in the presence of the Engineer.

D. The Job Mix Formula shall specify a combination of mineral aggregates including filler and bitumen (plus bitumen modifier if required) in such proportions to produce a Job Mix which is within the limits of the specified grading and bitumen content ranges and which meets the Marshall test requirements, as prescribed for each particular type of bitumen course. It shall also stipulate the mixing temperature at discharge from the mixer which, unless otherwise agreed by the Engineer, shall be 170^{o}C.

E. 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.

F. When compacting specimens in accordance with the Marshall Test procedure, the number of blows applied with the compaction hammer shall be 75 on each side, unless otherwise specified on the Drawings or instructed by the Engineer.

G. In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid antistripping agent, may be used 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 antistripping agent shall be provided in the range of 0.6-1.0% by weight of the bitumen, or according to the manufacturer's specifications.

H. Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to supply in the correct proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the job mix gradation limits given in Table 4.3.1.

TABLE 4.3.1: MAXIMUM VARIATIONS OF PROJECT MIX FROM APPROVED JOB MIX

Sieve Designation (Square Openings)	**Specified Tolerances**
9.5 mm and above:	+/- 5.0%
4.75 mm (No. 4):	+/- 4.0%
2.00 mm (No. 10):	+/- 4.0%
0.425 mm (No. 40):	+/- 4.0%
0.18 mm (No. 80):	+/- 4.0%
0.075 mm (No. 200):	+/-1.0%
Bitumen Content:	to be recommended by designer
Temperature of Mix on discharge:	+/- 5^{o}C

I. Any deviation from these limits shall be made only with the approval of the Engineer.

J. Conformance to gradation requirements shall be determined on the extracted aggregate in accordance with AASHTO T 30. The bitumen content shall be determined in accordance with AASHTO T 164.

K. The Engineer shall 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 reapproved by the Engineer and the plant readjusted to produce a new Job Mix.

L. The participation of the Engineer in the preparation of the Job Mix Formula shall not relieve the Contractor of his responsibility for producing project mixes meeting the specified requirements.

4.03.4 EQUIPMENT

A. General

Plant and equipment for mixing, transporting, spreading and compacting bituminous mixes shall conform with the requirements set in Volume 1 and to the Contractor's approved Work Programme.

B. Mixing Plant

B.1 Bituminous mixes shall be produced in a batch mixing plant of adequate size with a minimum capacity of not less than 80 tons/hr and a mixer capacity of not less than a 750 kg batch. The plant shall conform to the relevant requirements of AASHTO M 156.

B.2 A mechanical batch counter shall be installed as part of the timing device and shall be designed to register only completely mixed batches.

B.3 The mixing plant shall be fully equipped to control the gradation of hot dry aggregates and of cold damp aggregates. A suitable dust collection system shall be installed, capable of returning all dust to the mixture whenever required. Suitable filters shall be incorporated whenever the mixing plant is in the vicinity of inhabited areas, or whenever they are required by law.

B.4 The cold feed system shall be a continuous belt feed type or other system approved by the Engineer. It shall be easily modified to allow hydrated lime slurry to be added to the mix prior to heating and dry powdered lime to be added after heating.

B.5 An approved type automatic weighing, cycling and monitoring system shall be installed as part of the batching equipment. Facilities for easy sampling of the aggregates from the hot bins whilst the plant is in operation shall also be provided.

B.6 The use of a continuous mixing plant shall only be considered in special circumstances. If the Contractor proposes to use a continuous mixing plant for all or part of the bituminous mixing, full details of the plant including its in-service record and the manufacturer's specifications shall be submitted for approval by the Engineer before proceeding with the purchase or delivery to Site of such plant.

B.7 The Contractor shall systematically inspect and verify in the presence of the Engineer the following key operational aspects of the mixing plant on a weekly basis or whenever suspect,:

- The state of repair of the screens and their frame mountings
- Proper working of cold and hot bin gates
- The accuracy of batching scales for filler, aggregates and bitumen.
- Proper working of the nozzles of the mixer bitumen sprayer
- The state of repair of the paddle tips and liners of the mixer

B.8 The Contractor shall furnish for reference and retention by the Engineer one complete set of the manufacturer's instruction and operating manuals for the mixing plant intended for use.

B.9 At the commencement of the Contract, 2 copies each of the latest editions of the Asphalt Institute Specification SS-1 and Manuals MS-2, MS-3, MS-8 and MS-22 shall be furnished by the Contractor for use by the Engineer's supervisory staff and one copy of each shall be issued to each of the Contractor's senior staff involved in bituminous works. At the end of the Contract all the copies shall become the property of the Employer.

C. Spreading and Finishing Equipment

C.1 Bituminous courses shall be spread and finished using self-contained, power-propelled pavers of sufficient capacity to be capable of laying up to 80 ton/hr. Pavers shall be provided with electronically controlled vibratory screed or strike-off assemblies with devices for heating the screed and shall be capable of spreading and finishing the various courses of bituminous plant mix to the correct thickness and lane and shoulder widths applicable to the typical cross sections shown on the Drawings and in incremental widths down to 2.4 metres minimum and up to 8 metres maximum.

C.2 Pavers shall employ mechanical devices such as equalizing runners, straightedge runners, evener arms or other compensating devices to maintain the correct grade and confine the edges of the mix to the specified edge lines without the use of stationary side forms. Joint levelling devices shall be provided for smoothing and adjusting longitudinal joints between lanes.

C.3 Pavers shall be equipped with receiving hoppers having sufficient capacity for a uniform spreading operation. Hoppers shall be equipped with a distribution system to place the mix uniformly in front of the full length of the screed.

C.4 The screed or strike-off assemblies and extensions shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mix.

C.5 The paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mix. The speed shall be fully adjustable between 3 and 6 metres/minute.

C.6 Automatic controls shall consist of automatic linkage arrangements such that, through the process of adjusting the screed thickness control, the mix can be placed and finished to a predetermined grade and a uniform crown or cross section. Articulated averaging beams shall be at least 9 metres in length.

C.7 If during construction, the spreading and finishing equipment in operation leaves in tracks or indented areas or other irregularities in the pavement surface that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

C.8 The Contractor shall make available for reference by the Engineer the manufacturer's instruction and operating manuals for each paver intended for use.

4.03.5 CONSTRUCTION OF TRIAL SECTIONS

A. 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 wide by 50 metres long at approved locations close to the Site. Each trial section shall be laid using the same materials, Job Mix, mixing, spreading and compaction plant and spreading and compaction procedures proposed for use in the Works.

B. 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.

C. Each trial section shall also demonstrate the adequacy of hauling, spreading and compaction equipment and the suitability of the construction method and organization proposed.

D. If the trial section meets the required specification, the Job Mix Formula shall be approved by the Engineer.

E. The trial section shall be carried out at the Contractor's expense and shall be removed from Site, if so required by the Engineer.

4.03.6 MIXING PROCEDURES

A. Each aggregate ingredient shall be heated and dried such that the temperature recorded in the hot fines bin after screening shall not exceed 170 ^{o}C. If any aggregates contain excess moisture that may cause foaming in the mixture or their temperature is in excess of 170 ^{o}C, they shall be removed from the bins and disposed of as directed by the Engineer.

B. Immediately after heating, the aggregates shall be screened into at least 3 sizes and conveyed to separate bins ready for batching and mixing with the bitumen. When the aggregates furnished are of such size and grading that separating into 3 bins is impractical, the number of required separations may, if approved by the Engineer, be reduced to 2 only. 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.

C. 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. Immediately prior to bitumen entering the mixer, bitumen modifier or antistripping additive, if required, shall be thoroughly mixed with the bitumen which shall then be introduced into the pugmill mixer in the proportionate amounts determined by the Job Mix.

D. The temperature of the bitumen upon entering the pugmill shall be within 15^{o}C of the aggregate temperature. Unless otherwise directed, the bitumen temperature shall be as given in Table 4.3.2.

TABLE 4.3.2: BITUMEN PROPERTIES

Type and Grade of Bitumen	Viscosity (Centistokes)	Max. Temperature °C Immediately after discharge from Pugmill
85 - 100 pen.	170 + 20	160
60 - 70 pen.	170 + 20	165
40 - 50 pen.	170 + 20	170

E. Any mix subjected to higher temperatures than those shown in Table 4.3.2 shall be rejected.

F. 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 Engineer. This time shall be redetermined whenever the source of aggregate for the mix changes.

G. In batch plants, mixing time shall begin upon entry of bitumen into the pugmill.

H. Mixing time for continuous mixing plants shall be determined by the following formula or other approved method agreed with the Engineer:

Mixing time (sec) = Pugmill dead capacity (kg) divided by pugmill output (kg/sec)

4.03.7 SURFACE PREPARATION

A. When the bituminous mix is to be placed on a prepared subgrade, subbase or base, the surface shall be prepared to meet the appropriate specified compaction and surface tolerance requirements. The surface shall then be primed as specified in Section 4.02 - Bituminous Prime

and Tack Coats. No bituminous mix shall be laid on a prime coat until it has been inspected and approved by the Engineer.

B. When the bituminous mix is to be placed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. Any loose, broken or shattered bituminous material along the edges of the existing surface shall be removed and the exposed subgrade, and a sufficient width of the shoulder adjacent to the edge of the existing surface, shall be shaped, bladed, compacted and broomed to provide a uniform firm subgrade for the new surface course.

C. Broken, soft or unstable areas of existing bituminous surface, base or subgrade shall be removed and replaced. The areas shall be excavated to a depth as directed by the Engineer and refilled with the specified bituminous mix.

D. Prior to placing of the bituminous mix on an existing bituminous surface a tack coat as specified in Section 4.02 - Bituminous Prime and Tack Coats shall be applied to the existing surface at the rate determined by the Engineer. No mixture shall be laid on a tack coat until it has been inspected and approved by the Engineer.

4.03.8 DELIVERY, SPREADING AND FINISHING

A. Delivery of Mix to Site

A.1 A sufficient number of haul vehicles shall be provided so that adequate supplies of mix are delivered to ensure paving is a continuous operation.

A.2 Hauling equipment for aggregates and bituminous mixes shall consist of trucks having dump bodies suitable for tipping materials in a windrow or in spreader boxes. The bodies shall be constructed so that volume measurements can be accurately determined. They shall be constructed and maintained such that loss of materials during hauling operations will not occur. Dump controls shall be capable of operation from the driver's seat.

A.3 Hauling equipment for hot bituminous mixes shall have tight, clean, smooth metal surfaces which are periodically thinly coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type cover which shall be used to cover the hot material upon loading at the mixing plant and shall not be removed until the mix is discharged into the paver. Hot mix material may be transported without such cover only when permitted by the Engineer and in special circumstances.

A.4 The dispatching of the hauling vehicles to the Site shall be scheduled so that all material delivered is placed at least 90 minutes before sunset to allow sufficient time for compaction, unless the use of artificial light has been approved by the Engineer. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

A.5 The mix at delivery to the paver shall be not more than 10^{o}C below the discharge temperature at the mixing plant. The minimum temperature for the commencement of compaction is 120^{o}C. Mix loads with temperatures less than 120^{o}C shall not be accepted, and the load shall be disposed of and another load used. If there is a consistent failure to meet the temperature requirement the Engineer shall order paving operations to stop until suitable measures are taken by the Contractor to ensure that temperature requirements are met.

A.6 Each haul vehicle shall be weighed after each loading at the mixing plant and accurate records shall be kept of the gross and net weight, date and time of loading for each load.

B. Setting Out and Reference Lines

B.1 The Contractor shall survey the centreline profile and crown of the existing surface or base and determine a reference grade line which shall be submitted to the Engineer for approval. A reference line of wire or suitable cord shall be installed at a uniform grade parallel to the approved reference grade line such that conformance with the required geometrics, surface tolerance and minimum thickness requirements shall be ensured. The reference line shall be supported at 8 metre maximum spacing unless there is noticeable sag in the line or the pavement surface, in which case the maximum spacing shall be 4 metres.

B.2 The reference line shall be maintained taut and free from sags at all times during spreading and initial compacting operations.

B.3 Except where the paver is matching a previously placed layer, a wire or cord reference line shall be installed on both sides of the paver for the initial bituminous course being laid. Thereafter only one reference line shall be required if the paver is equipped with adequate automatic superelevation control.

C. Spreading and Finishing

C.1 Bituminous mixes shall only be laid when the air temperature is at least 5 ^{o}C or above and the surface temperature of the underlying course is at least that specified in Table 4.3.3, when the existing surface is free from moisture and when the weather is not foggy, rainy, dusty or excessively windy. The temperature requirements shall only be waived when so directed by the Engineer.

TABLE 4.3.3: MINIMUM SURFACE TEMPERATURES FOR ASPHALT CONSTRUCTION

Asphalt Course Thickness	**Minimum Surface Temperature ^{o}C**
75 mm or greater	4
Greater than 25mm but less than 75mm	7
25mm or less	10

C.2 After completion of surface preparation the bituminous mix shall be spread and finished true to crown and grade by approved automatically controlled bituminous pavers. The

mix shall only be spread and finished by approved hand methods when Engineer determines that machine methods are impracticable. Hand methods shall include heated hand tampers of at least 10 kg weight and mechanical (vibratory) tampers of types approved by the Engineer.

C.3 The paver shall spread the bituminous mix without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture and free from hollows, transverse corrugations and other irregularities.

C.4 The paver shall be operated at a speed which gives the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mix to the paver. A uniform rate of placement shall be achieved without repeated intermittent operation of the paver.

C.5 The mix shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mix during daylight hours.

C.6 If during laying the paver is repeatedly delayed because of lack of supply or if the paver stands at one location for an extended period resulting in the (unrolled) mat under and adjacent to the rear of the spreader falling below the minimum temperature for breakdown rolling, the affected portion of mat shall be cut out and discarded and a transverse joint constructed. Paving shall not recommence until the Engineer is satisfied that paving can proceed without interruption.

C.7 Contact surfaces of kerbing, gutters, manholes and similar structures shall be painted with a thin, uniform coating of tack coat material. The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be 10 mm above the edge of such structure.

C.8 If during the paving operations the spreading and finishing equipment in operation leaves surface tracks or indented areas or other objectionable irregularities in the pavement that are not satisfactorily corrected by the scheduled operations, the use of the equipment shall be discontinued, until faults are corrected to the approval of the Engineer. If this is not possible, other satisfactory spreading and finishing equipment shall be provided by the Contractor.

C.9 Where successive bituminous layers are to be placed, the surface of each existing layer shall be swept clean with a power broom, or by other approved means and a tack coat applied at the rate designated by the Engineer and in accordance with the relevant requirements of Section 4.02 - Bituminous Prime and Tack Coats.

C.10 Transverse joints in succeeding layers shall be offset by at least 2 metres. Longitudinal joints shall be offset at least 150 mm.

C.11 The bituminous mix shall be spread in one or more layers in order that after rolling the nominal thickness of each layer of the compacted bituminous material does not exceed 3 times the maximum size of aggregate. This maximum thickness may be increased slightly when such an increase is more appropriate to total pavement thickness and provided the Engineer determines that such an increased thickness will not be detrimental to the quality of the finished

bituminous course and the Contractor can show that the required density is attained throughout the layer thickness.

C.12 Transitions and structure approaches shall meet the design criteria for geometry and surface tolerance specifications and shall not be visually discontinuous or abrupt in appearance.

C.13 Side roads, entrances and lay-bys shall be paved in accordance with the details shown on the Drawings.

D. Joints and Edges

D.1 All joints between old and new pavements or between successive days' work shall provide thorough and continuous bonds between the old and new material.

D.2 Before placing a fresh mix against previously laid or against old pavement, the contact surface shall be cut back to a near vertical face and shall sprayed or painted with a thin uniform coat of tack coat material unless otherwise directed by the Engineer. Longitudinal joints shall be made by overlapping the paver screed on the previously laid material (cut back as necessary) and depositing a sufficient amount of fresh mix so that the joint formed is smooth and tight.

D.3 The Contractor shall schedule paving operations to minimize exposure of longitudinal joints prior to the completion and compaction of joints. The leading lane shall not be laid in advance of the adjacent trailing lane by more than one half day of paving and the leading lane shall not be laid more than 0.5 km ahead of the trailing lane without the Engineer’s approval. In the event of failure to conform to these requirements, the Engineer shall suspend paving on the leading lane.

D.4 Unsupported edges of bituminous layers shall be rolled immediately following the rolling of the longitudinal joint. The material along the unsupported edge may, with the Engineer’s approval, be raised slightly by hand methods to ensure that the full weight of the roller will bear fully on the edge material.

D.5 On completion the longitudinal edges of bituminous pavement shall be true to the width and alignment as shown on the Drawings. The edges shall be cut back if necessary prior to rolling, additional mix placed manually in a longitudinal strip adjoining each pavement edge and the edge rolled down to a neat 3:1 (H:V) slope or as shown on the Drawings.

D.6 Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be straight-edged and string-lined to assure smoothness and a true alignment. If the joint is formed with a bulkhead, such as a board, to provide a straight line and vertical face, it shall be checked with a straight edge before fresh material is placed against it to complete the joint. If a bulkhead is not used to form the joint and the roller carries over the end of the new material, the line shall be cut back a sufficient distance to provide a true surface and cross-section. If the joint has been distorted by traffic or by other means, it shall be trimmed to line. In either case, the joint face shall be painted with a thin coating of bitumen before the fresh material is placed against it.

E. Compaction

E.1 Rollers shall be operated by competent and experienced operators in accordance with the manufacturer's instructions, copies of which shall be submitted to the Engineer. Rollers shall be kept in operation continuously during paving operations so that all parts of the pavement receive substantially equal compaction at the time desired.

E.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.

E.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. The minimum numbers of rollers required is 3, of which one shall be a pneumatic type. The Contractor shall select a suitable method and pattern of rolling that will achieve the required compaction, to the Engineers approval.

E.4 Prior to use on site of pneumatic-tired rollers, the Contractor shall furnish, for reference and retention by the Engineer, manufacturers' charts or tabulations showing the contact areas and contact pressures for the full range of tyre inflation pressures and for the full range of tire loadings for each type and size of compactor tire to be used. The Contractor shall ensure that tyre pressures are maintained at all times in conformity with such charts or tabulations. The maximum allowable tolerances shall be plus or minus 35 kN/m^2.

E.5 Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Recommended speeds are shown in Table 4.3.4.

TABLE 4.3.4 RECOMMENDED SPEEDS OF ROLLERS (Km/Hr)

	Breakdown	Intermediate	Finish
Steel Tired Static Weight Rollers	3	5	5
Pneumatic Tired Rollers	5	5	9
Vibratory Rollers	4.5	4.5	-

E.6 If vibratory rollers are used the vibration mechanism shall be turned off before changing direction before the roller has stopped and turned on again on completion of the manoeuvre.

E.7 Rolling shall begin as soon as the mixture will bear the roller weight without undue displacement. The minimum temperature of the mat at which rolling shall be allowed to start is 120^oC.

E.8 Breakdown rolling shall consist of 3 complete coverages unless otherwise directed. Rolling shall be longitudinal, beginning at the low side of the spread of material and

proceeding towards the high side, overlapping on successive trips by at least one half the width of the rear wheels. Alternate passes of the rollers shall be of slightly differing lengths.

E.9 The speed of the rollers, rolling pattern and, in the case of vibratory rollers, the frequency and amplitude of vibration shall be approved by the Engineer. 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 shall not be permitted.

E.10 The rolling pattern, type and number of rollers shall be established by a site trial to achieve the required compaction. The established rolling pattern shall be follows.

E.11 The initial or breakdown rolling shall be followed by intermediate rolling involving passes with pneumatic-tired rollers unless otherwise specified. Tyre contact pressure shall be as approved by the Engineer.

E.12 Finishing rolling shall be carried out by means of tandem power steel rollers unless otherwise agreed by the Engineer. If the specified density is not achieved, changes shall be made in size and number of rollers being used to ensure the compaction requirements are met.

E.13 The compacted density for all bituminous courses shall be equal to or greater than 97% of the average Marshall bulk specific gravity for each day's production unless otherwise directed by the Engineer.

E.14 Any mix that becomes loose, broken, mixed with foreign material or which is defective in finish or density or which does not conform in all other respects with the specified requirements shall be removed and replaced with suitable material and properly finished.

4.03.9 SAMPLING AND TESTING

A. Sampling and testing shall conform to the relevant requirements of Part 1 of the Specifications, Section 4-6 "Samples and Approvals", and Table 4.3.5.

TABLE 4.3.5: TESTS FOR BITUMINOUS PAVEMENTS: MINIMUM REQUIREMENTS

Work Item	Test at Source of Material	Frequency	Test at Road Site	Frequency
4-1 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	For each source **and** When material quality changes **and** When requested by the Engineer		
4-2 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	For each source **and** When material quality changes **and** When requested by the Engineer		
4-3 Asphalt Mix Design (each layer) (At Batching Plant)	1- Complete mix design 2- Loss of stability	For each Project **and** When material quality changes **and** When results are not consistent with the mix design results **and** When requested by the Engineer		
4-4 Asphalt for each layer	<u>At Batching Plant</u> 1- Stability 2- Flow 3- Binder content and gradation 4- Air voids 5- Voids in mineral aggregates 6- Daily Marshall density	Every 3 working days **and** For each batching plant **and** When requested by the Engineer	<u>Behind Spreader</u> 1- Stability 2- Flow 3- Binder content & gradation 4- Air voids 5- Voids in mineral aggregates 6- Marshall density	Every working day **and** Test for each batch **and** When requested by the Engineer
	7- Loss of Stability	Every week **and** When requested by the Engineer	7- Road density and thickness (after final compaction)	Every 200m per lane and each layer **and** When requested by the Engineer

B. The Marshall bulk specific gravity shall be determined in accordance with AASHTO T 166. The Marshall specimens shall be prepared from the same material used in the construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the Site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.

C. The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples or slab samples cut from each compacted layer on the road at locations selected by the Engineer. The Engineer reserves the right to instruct additional tests to determine the limits of areas deficient in density or for verification.

D. Samples for in situ bulk specific gravity determinations shall be taken in sets of two from each pavement location. The minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placed bituminous layers.

E. The Contractor shall cut the samples with an approved core drill in the presence of the Engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen.

F. The Contractor shall, when necessary, furnish and apply cold water, ice, or other cooling substance to the surface of the pavement to prevent the sampling from shattering or disintegrating. The Contractor shall fill and compact all test holes at his own expense.

4.03.10 SURFACE TOLERANCES

A. The fully compacted and completed bituminous course shall conform to the lines, grades and cross sections as shown on the Drawings.

B. The elevations of the finished course shall be checked by the Contractor in the presence of the Engineer at maximum intervals of 10 metres and at intermediate points as directed.

C. When the finished surface is tested with a 3 metre long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed the tolerances specified for each type of bituminous course laid.

D. All areas which exceed the specified tolerances shall be corrected by removing the defective sections of bituminous course and reconstructing them or by adding new material and recomposing and finishing to the specified standard or increasing the thickness of the succeeding course.

E. The tolerances specified for evenness of finished surfaces for all types of bituminous courses shall not invalidate the tolerances specified for construction thickness and elevations of such courses.

4.03.11 DETERMINATION OF LAYER COURSE THICKNESSES.

A. The Contractor shall compensate for minor deficiencies in the thickness of any bituminous course in the pavement structure by increasing the thickness of the subsequent bituminous course. After completion of the final (wearing) course any deficiencies in the thickness of any course which have not been compensated for by increasing the thickness of a subsequent course, shall be considered as deficiencies in the final (wearing) course.

B. Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.

C. Thicknesses of bituminous courses shall be determined by calliper measurements of cores, rounded upwards to the nearest mm.

D. Paved sections to be measured separately shall consist of 300 metre sections in each traffic lane. The last section in each traffic lane shall be 300 metres plus the fractional part of the 300 metres remaining. Other areas such as intersections, entrances, crossovers and ramps shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.

E. One core shall be taken from each section by the Contractor at locations approved by and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5 mm from the specified thickness, the core shall be deemed to be of the specified thickness as shown on the Drawings.

F. When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 20 mm, 2 additional cores spaced at not less than 100 metres shall be taken and used together with the first core to determine the average thickness of such a section.

G. When the measurement of the core from any paved section is less than the specified thickness by more than 20 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 metre intervals parallel to the centreline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 20 mm. Exploratory cores for deficient thicknesses shall not be used in average thickness determinations.

H. Any deficiencies in the total thickness of bituminous courses shall be subject to a proportional reduction in the volume of final (wearing) course measured for payment. Alternatively, the Contractor shall construct, at his own expense, a wearing course overlay if practicable in the judgement of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thickness and to the specified standard of the course it is overlaying.

I. If the deficiency in total asphalt layers thickness is from 0 - 3mm, full payment will be made, on condition that deficiencies are not found in more than 10% of the total project. For deficiencies between 3mm and 10mm, 80% of the full payment for the bituminous courses shall be made.

4.03.12 MEASUREMENT

A. Bituminous Courses shall be measured as prescribed in each of the respective Sections for each type of bituminous course constructed and accepted. Measurement shall not include the rolled edge strips of bituminous courses placed outside the edge of paving as shown on the Drawings.

B. Bituminous prime and tack coats shall be measured as prescribed in Section 4.02 - Bituminous Prime and Tack Coats.

C. Bituminous overlays constructed to correct deficiencies in total thickness of bituminous courses or to compensate for major deficiencies in the thickness of any underlying bituminous course, shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which shall be deemed to be included in the Contract Prices for Pay Items.

D. Establishment of the Job Mix Formula, surface preparation, construction of joints, hand painting of contact surfaces, remedial treatment of surface irregularities, cutting of cores and slabs for testing or measurement purposes, reinstatement of core and slab areas of pavement, rolled down longitudinal bituminous edge strips, additional thicknesses of bituminous courses in excess of the specified thickness and other ancillary items shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which shall be deemed to be included in the Contract Prices for Pay Items.

SECTION 4.04 BITUMINOUS BASE COURSE

4.04.1 SCOPE

The work covered in this Section consists of furnishing materials, mixing at a central mixing plant and spreading and compacting bituminous base course on an approved granular base, subbase or subgrade as and where shown on the Drawings.

4.04.2 MATERIALS

A. All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

B. Unless otherwise shown on the Drawings, bitumen for base course construction shall be 60/70 penetration graded bitumen.

C. When an approved modifier is to be added and mixed with the bitumen, the bitumen used shall not be of lower penetration than 80/100 grade.

4.04.3 JOB MIX AND PROJECT MIX

A. The Job Mix Formula shall be established by the Contractor in accordance with the procedures and requirements of Section 4.03 - Bituminous Courses.

B. The Job Mix for bituminous base course shall conform to the following composition limits shown in Table 4.4.1.

TABLE 4.4.1: JOB MIX REQUIREMENTS FOR BITUMINOUS BASE COURSE

Marshall Stability at 60ºC (Kg)	700
Flow (mm)	2 - 3.5
Voids in Mineral Aggregate (VMA)	12 (min)
Air Voids (%)	4 - 8

C. After the Job Mix Formula has been established and approved by the Engineer, all mixes furnished shall conform to it within the stated tolerances.

D. The Job Mix Formula shall be re-established if the source of aggregate, filler or bitumen changes.

4.04.4 EQUIPMENT

Plant and equipment for mixing, hauling, placing and compacting bituminous base course material shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

4.04.5 CONSTRUCTION OF TRIAL SECTIONS

Trial sections shall be constructed as and where directed by the Engineer and in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

4.04.6 MIXING PROCEDURES

Handling and mixing of bitumen (including modifier and antistripping agent, if any) and aggregates (including mineral filler if required) shall be in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

4.04.7 SURFACE PREPARATION

Preparation of the surfaces upon which the bituminous base course mix is to be laid shall be appropriate to the type and condition of such surfaces and shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

4.04.8 DELIVERY, SPREADING AND FINISHING

A. General

The delivery, spreading and finishing of bituminous mix for base course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

B. Rollers

B.1 Initial breakdown rolling shall be carried out using 2 dual-drum vibrating steel-wheeled vibrating rollers each of a minimum weight of 7,000 kg and with vibrating frequency of 2,000-3,000 cycles/min. These rollers shall be purpose-made for compaction of hot bituminous courses.

B.2 Intermediate rolling shall be carried out using least 2 self-propelled, tandem pneumatic smooth-tired rollers each capable of exerting contact pressures of up to 690 kN/mm^2 and ballast - adjustable to ensure uniform wheel loadings.

B.3 Final rolling shall be carried out using two 2-axle tandem steel-tired rollers each of minimum weight 10,000 kg, capable of exerting contact pressures of up to 65 kg/cm.

B.4 The number of rollers used for any stage of rolling may be reduced by the Engineer to one, provided that the base course width being compacted is less than 5.5 m in width, and provided an equivalent standby roller is available on Site as a replacement in the event of breakdown of the operating roller.

C. Standard of Compaction

The compacted density of the bituminous base course shall be equal to or greater than 97% of the average Marshall bulk density for each day's production.

4.04.9 SAMPLING AND TESTING

Sampling and testing shall conform to the relevant requirements of Section 4.03 - Bituminous Courses, and Table 4.3.4.

4.04.10 SURFACE TOLERANCES

A. Surface tolerances shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

B. The tolerances on elevations of the finished bituminous base course surface shall be not greater than plus 10 mm or less than minus 10 mm.

C. When the finished surface is tested with a 3 metre long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed 8 mm.

4.04.11 DETERMINATION OF THICKNESS

A. Procedures for determining the average compacted thickness of bituminous base course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

B. Cores for thickness measurements shall be used to determine if changes are necessary in the constructed thickness of succeeding bituminous layers to rectify any thickness deficiencies in the bituminous base course.

C. Where the bituminous base course is not to be covered by a superimposed wearing course, the base course shall be deemed to be the final (wearing) course for the purposes of determining the proportion of wearing course volume measured for payment or for the purposes of any overlay ordered to correct deficiencies.

4.04.12 MEASUREMENT

A. Bituminous Base Course shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thickness as shown on the Drawings or as otherwise directed by the Engineer.

B. Where Bituminous Base Course is intended to serve as a wearing course, any deficiencies in thickness shall, unless an overlay is constructed at the Contractor's expense, result in a proportion only of the base course volume being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies presented in Section 4.03 - Bituminous Courses.

C. The rate for Bituminous Base Course used in temporary diversions shall also include for removal and disposal of the base course material and reinstatement of the temporary diversion, to the satisfaction of the Engineer, on completion of use.

D. Bituminous prime and tack coats shall be measured as prescribed in Section 4.02 - Bituminous Prime and Tack Coats.

SECTION 4.05 BITUMINOUS WEARING COURSE

4.05.01 SCOPE

A. The work covered in this Section consists of furnishing materials, mixing at a central mixing plant and spreading and compacting bituminous wearing course on an approved base course as and where shown on the Drawings.

B. Bituminous wearing course material consists of a surface course composed of mineral aggregate, filler and bituminous material mixed in a central mixing plant and placed on a prepared lower asphalt or road base course in accordance with these Specifications and conforming to the lines, grades, thicknesses and typical cross sections shown on the Drawings or as indicated by the Engineer.

4.05.02 MATERIALS

All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction and the following:

A. Aggregate

A.1 Coarse Aggregate

A.1.1 Coarse aggregate shall show the following properties:

Property	Material		
	Limestone	Basalt	Other
Los Angeles Abrasion (ASTM C 131)	30% maximum	20% maximum	20% maximum
Sodium Sulphate Soundness (ASTM C 88)	12% maximum, 9% maximum on sites over 1000m above sea level	6% maximum	12% maximum, 9% maximum on sites over 1000m above sea level
Magnesium Sulphate Soundness (ASTM C 88)	18% maximum, 14% maximum on sites over 1000m above sea level	9% maximum	18% maximum, 14% maximum on sites over 1000m above sea level
Polish Stone Value	40 minimum	45 minimum	45 minimum

A.1.2 The aggregate shall not contain more than 8% by weight of flat or elongated pieces. A flat particle is one having a ratio of width to thickness greater than three; an elongated particle is one having a ratio of length to width greater than three.

A.1.3 If instructed by the Engineer or detailed in the Contract Documents and Drawings coarse aggregate shall consist wholly or partly of unweathered basalt rock meeting all the requirements of A.1.1 and A.1.2 above.

A.2 Fine Aggregate

A.2.1 Fine aggregate shall consist of clean, sound, durable, angular particles produced by crushing stone that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt and other deleterious substances and shall contain no clay particles. The fine aggregate, including any blended filler, shall have a plasticity index of not more than 4% when tested in accordance with ASTM D 424 and a liquid limit of not more than 25% when tested in accordance with ASTM D 423.

A.2.2 If necessary natural sand may be used to obtain the target gradation of aggregate blend or workability. Beach sand shall not be used in any asphalt mix. The amount of sand to be added shall be adjusted to produce mixtures conforming to the requirements of this section. If it is necessary to add natural sand, the percentage shall be kept below 10% of the weight of the mix.

A.3 Sampling and Testing

A.3.1 Sampling and testing shall conform to the relevant requirements of Section 4.03: - Bituminous Courses and the following.

A.3.2 ASTM D 75 shall be used for sampling coarse and fine aggregate and ASTM C 183 for sampling mineral filler.

A.4 Sources of Aggregates

A.4.1 To ensure consistency in the quality of supply of aggregates sourced from remote quarries, materials sourced more than 50 Km from site and/or from other countries shall be delivered to site and stockpiled prior to construction in order for sufficient compliance testing to be carried out on all the material before its incorporation into the Works.

A.4.2 The Contractor shall monitor all aggregate extraction, crushing and testing at the source quarries. A method statement shall be prepared by the Contractor and approved by the Engineer detailing his proposed staffing at the source quarries by competent personnel as part of the materials approvals process.

B. Filler

B.1 If additional filler is necessary, it shall meet the requirements of ASTM D 242.

B.2 The maximum amount of lime or cement replacing natural filler in the mix to aid adhesion shall be 2% by weight of filler.

C. **Bitumen Binder**

The type, grade, controlling specifications and maximum mixing temperatures for the bitumen binders for wearing course are as follows:

- Penetration grade (roads below 1000 m): 40-50
- Penetration grade (roads above 1000 m): 60-70
- Specification: ASTM D 946
- Maximum mixing temperature ^{o}C: 170

4.05.03 JOB MIX AND PROJECT MIX

Wearing course job mixes shall be formulated in accordance with the relevant requirements of Section 4.03 - Bituminous Courses and the following:

A. **Air Voids Analysis**

A.1 The design range of air voids (3 to 5%) shall be the level desired after several years of traffic.

A.2 The laboratory compactive effort shall be selected for the expected traffic demand. For reference the design air voids range will normally be achieved if the mix is designed at the correct compactive effort and the percentage air voids after construction is about 8%. Some consolidation with traffic is expected and desired. Mixtures that ultimately consolidate to less than 3% air voids can be expected to rut and shove if placed in heavy traffic locations. Brittleness, premature cracking, ravelling and stripping can occur if the final air voids content is above 5% or if the pavement is constructed with over eight percent air voids.

A.3 The overall objective shall be to limit adjustments of the design asphalt content to less than 0.5 percent air voids from the median of the design criteria in Table 4.5.1.

B. **Mix Design**

B.1 The bituminous mixture shall be designed using procedures contained in Chapter 5, Marshall Method of Mix Design, of the Asphalt Institute's Manual Series No. 2 (MS-2), sixth edition, and shall meet the requirements of Tables 4.5.1 and 4.5.2 overleaf.

B.2 The Contractor shall prepare a series of test specimens with a range of different binder contents so that the test data show a well-defined curve. Tests shall be scheduled on the basis of 0.5% increments of binder content, with at least two binder contents above optimum and at least two below optimum.

B.3 Triplicate test specimens shall be prepared for each binder content mix to be tested.

B.4 The mineral aggregate shall be of such a size that the percentage composition by weight, as determined by laboratory sieves, shall conform to the gradation or gradations specified in Table 4.5.3 overleaf, when tested in accordance with ASTM Standard C 136 (dry sieve only). The percentage by weight for the bituminous material shall be within the limits specified.

TABLE 4.5.1: MARSHALL DESIGN CRITERIA

Test	**Value**
Number of blows	75
Stability, minimum in kilograms	900
Flow, in mm	2 – 3.5
Percent air voids	3% Normal Traffic (< 1 m ESAL) 4% Heavy Traffic (1- 5 m ESAL) 5% Very Heavy Traffic (>5 m ESAL)
Percent voids in mineral aggregate	See table 4.5.2
VFA %	65 – 75% (Normal to Heavy Traffic) 65-73% (Very Heavy Traffic)
Dust to bitumen ratio	1.2 maximum

TABLE 4.5.2: MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE

ASTM SIEVE	**MAXIMUM PARTICLE SIZE mm**	**MINIMUM VOIDS IN MINERAL AGGREGATE PERCENT DESIGN AIR VOIDS**		
		3%	**4%**	**5%**
13 mm	12.5	13	14	15
18 mm	19.0	12	13	14
25 mm	25.0	11	12	13
37 mm	37.5	10	11	12

TABLE 4.5 3: AGGREGATE GRADING LIMITS - ASPHALT WEARING COURSE

ASTM Sieve Size	Percentage by Weight Passing Sieves		
	25mm	**18mm**	**13mm**
38mm	100	-----	-----
25mm	90 - 100	100	-----
18mm	------	90-100	100
13mm	56 - 80	-----	90 - 100
No. 4	------	56 - 80	------
No. 8	29 - 59	35 - 65	44 - 74
No. 16	19 - 45	23 - 49	28 - 58
No. 30	------	-------	-------
No.50	------	------	------
No.100	5 - 17	5 - 19	5 - 21
No. 200	1-7	2-8	2-10
Bitumen Content %	4.5 - 7.0	5.0 - 7.5	5.5 - 8.0

B.5 Bitumen content shall be calculated by weight of total mixture.

B.6 The compacted thickness of any layer shall be at least twice the maximum nominal size of the aggregate band for wearing course unless otherwise directed by the Engineer.

B.7 In considering the total grading characteristics of a bituminous paving mixture, a higher percentage of material passing the No. 8 (2.36 mm) sieve will result in pavement surfaces having a comparatively fine texture, while coarse gradings approaching the minimum amount passing the No. 8 sieve will result in surfaces with comparatively coarse texture.

B.8 The gradations in Table 4.5.3 represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The selection of any of the gradations shown in table 3 shall be such that the maximum size aggregate used shall not be more than one-half of the thickness of the layer of the course being constructed. The maximum aggregate size that shall be used in surface course shall be 25mm unless otherwise directed by the Engineer.

B.9 The aggregate shall have a gradation within the limits designated in Table 4.5.3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

B.10 The job mix tolerances shall be as shown in table 4.5.4 overleaf and shall be applied to the Job Mix Formula to establish a job control grading band. The limits of the master grading band as specified in table 4.5.3 shall apply if the application of the job mix tolerances results in a job control grading band outside the master grading band.

TABLE 4.5 4: JOB MIX FORMULA TOLERANCES - ASPHALT WEARING COURSE

Material	**Tolerance**
Aggregate passing No.1/2" (12.5 mm) sieve	± 8%
Aggregate passing No.3/8" and No. 4 sieves	± 7%
Aggregate passing Nos. 8, 16, No. sieves	± 6%
Aggregate passing Nos. 30 and 50 sieves	± 5%
Aggregate passing No. 200 sieve	± 3%
Bitumen %, weight % by total mix	0.50%
Temperature of mix	11 ^{O}C

B.11 The aggregate gradation may be adjusted within the limits of table 4.5.3 without adjustments to the Contract unit prices.

B.12 Should a change in source of materials be made, a new Job Mix Formula shall be established before the new material is used. Deviation from the final approved design for bitumen content and gradation of aggregates shall not be greater than the tolerances permitted and tests for bitumen content and aggregate gradation shall be made at least twice daily. The mixture shall be tested for bitumen content in accordance with ASTM D 2172 and for aggregate gradation in accordance with ASTM C 136.

B.13 If the index of retained strength of the specimens of composite mixture, as determined by ASTM D 1075, is less than 75 the aggregates shall be rejected or the asphalt shall be treated with an approved anti-stripping agent. The amount of anti-stripping agent added to the asphalt shall be sufficient to produce an index of retained strength of not less than 75.

4.05.4 EQUIPMENT

Plant and equipment for mixing, hauling, placing and compacting bituminous wearing course materials shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

4.05.5 CONSTRUCTION OF TRIAL SECTIONS

Trial sections shall be constructed as and where directed and in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

4.05.6 MIXING PROCEDURES

Handling and mixing of bitumen (including modifier and antistripping agent, if any) and aggregates (including mineral filler if required) shall be in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

4.05.7 SURFACE PREPARATION

Preparation of the surface upon which the bituminous wearing course mix is to be laid and the use of prime and tack coats shall be appropriate to the type and condition of such surfaces and shall conform with the relevant requirements of Section 4.03 - Bituminous Courses.

4.05.8 DELIVERY, SPREADING AND FINISHING

A. General

The delivery, spreading and finishing of bituminous mixes for wearing course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

B. Rollers

B.1 Initial rolling shall be carried out by use of two dual-drum vibrating steel-wheeled vibrating rollers each of minimum weight 7,000 kg and with vibrating frequency of 2,000-3,000 cycles/minute. These rollers shall be purpose made for compaction of hot bituminous courses.

B.2 Intermediate rolling shall be carried out by use of at least two self-propelled, tandem pneumatic smooth-tired rollers each capable of exerting contact pressures of up to 690 kN/m^2 and ballast - adjustable to ensure uniform wheel loadings.

B.3 Final rolling shall be carried out by use of two, 2-axle tandem steel-tired rollers each of minimum weight 10,000 kg, capable of exerting contact pressures of up to 650 kN/m^2.

B.4 The number of rollers used for any stage of rolling may be reduced by the Engineer to one, provided that the course being compacted is less than 5.5m in width and provided an equivalent standby roller is available on Site as replacement in the event of breakdown of the operating roller.

C. Standard of Compaction

The compacted density of the bituminous wearing course shall be not less than 97% of the average Marshall Bulk Density for each day's production.

4.05.9 SAMPLING AND TESTING

Sampling and testing shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

4.05.10 SURFACE TOLERANCES

A. Surface tolerances shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

B. The tolerances on elevations of the final bituminous wearing course surface shall not be greater than ± 6mm.

C. When the finished wearing course surface is tested with a 3m long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any two contact points shall not exceed 6 mm.

D. The combination of the permitted tolerances in the levels of the different pavement layers, excluding aggregate base course, shall not result in a reduction of thickness by more than 10mm from the specified thickness shown on the Drawings or a reduction in the final wearing course thickness by more than 5mm from that specified or shown on the Drawings.

4.05.11 DETERMINATION OF THICKNESS

A. Procedures for determining the average compacted thickness of bituminous wearing course shall conform with the relevant requirements of Section 4.03 - Bituminous Courses and to the following particular requirements.

B. Cores for thickness measurements of the bituminous base course shall be used to determine if changes are necessary in the constructed thickness of the wearing course to rectify any thickness deficiencies in the bituminous base course.

4.05.12 MEASUREMENT

A. Bituminous Wearing Course shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thickness as shown on the Drawings or otherwise directed by the Engineer. Separate measurements shall be made for Bituminous Wearing Course containing basalt or other hard aggregate when specified elsewhere in the Contract Documents or Drawings or by the Engineer.

B. Deficiencies in thickness of the wearing course shall, unless an overlay is constructed at the Contractor's expense, result in a proportion only of the wearing course area being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies presented in Section 4.03 - Bituminous Courses.

C. The rate for bituminous wearing course used in temporary diversions shall also include for removal and disposal of the wearing course material and reinstatement of the temporary diversion, to the satisfaction of the Engineer, on completion of use.

D. Bituminous prime and tack coats shall be measured as prescribed in Section 4.02 - Bituminous Prime and Tack Coats.

SECTION 4.06: BITUMINOUS SEAL COATS AND SURFACE DRESSINGS

4.06.01 SCOPE

A. The work covered in this section consists of the furnishing of materials for one or more applications of cutback bitumen and stone aggregate material or a single application of emulsified bitumen or spreading emulsified bitumen slurry to a previously prepared base or wearing course surface as and where shown on the Drawings.

B. Bituminous Slurry Seal Coat (**BSSC**) shall consist of spreading and screeding a mixture of emulsified bitumen, sand, aggregate and water.

C. Single Bituminous Surface Dressing (**SBSD**) shall consist of a single application of cutback or straight run bitumen and stone or sand aggregate as specified.

D. Double Bituminous Surface Dressing (**DBSD**) shall consist of an application of cutback or straight run bitumen and (coarse graded) aggregate followed not less than 5 days later by a second application of cutback or straight run bitumen and (medium graded) aggregate as specified.

4.06.02 MATERIALS

A. Bitumen

A.1 Bitumen for SBSD and DBSD applications shall be Rapid-Curing RC-800 Grade conforming to the relevant requirements of Section 4.01 - Materials for Bituminous Construction and AASHTO M-81.

A.2 Bitumen for BSSC (slurry) applications shall be cationic slow setting emulsified bitumen Grade CSS-1 or CSS-1h conforming to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

B. Aggregates

B.1 Surface dressing aggregates shall consist of screenings of crushed stone. Aggregate for slurry seals shall consist of crushed stone fines or natural sand blended with not less than 50% crushed fines. For heavy duty applications slurry aggregate shall consist of 100% crushed fines.

B.2 The properties of cover and slurry seal aggregates and their gradations shall be in accordance with the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

4.06.03 EQUIPMENT

All plant and equipment used for pugmill mixing of slurry mixes, heating and spraying of cutback and emulsified bitumen, spreading, rolling and brooming of cover aggregate and applying and spreading slurry seals shall conform with the requirements of Part 1, Section 4-4 - Contractor's Plant and Equipment.

4.06.04 CONSTRUCTION OF TRIAL SECTIONS

A. Before commencement of site seal coat applications, the Contractor shall construct trial sections using varying application rates for bitumen and for aggregates, as selected by the Engineer. Each trial section shall be 2 lanes wide by 50 metres long at locations approved by the Engineer on or close to the Site.

B. Each trial section shall be constructed using the same materials, mixing, spraying, spreading, rolling and brooming equipment and construction procedures proposed for use in the Works. Trial sections for slurry seals shall be along existing bituminous pavements in the vicinity of the Site.

C. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment, the most suitable application rates for cutback bitumen, emulsified bitumen and the various gradations of aggregate and the most suitable consistency of slurry seal to fill cracks and leave a residual coating of 3 mm over the entire bituminous wearing surface.

D. The Contractor shall not proceed with any seal coat applications until the methods and procedures established in the trials have been approved by the Engineer.

4.06.05 RATES OF APPLICATION

A. Application rates for cutback and emulsified bitumen and for aggregates shall be determined by the Engineer from the trial sections and shall be generally within the ranges given in Table 4.6.1.

Table 4.6.1: TYPICAL SEAL COAT APPLICATION RATES

Types of Seal Coat	**Rate of Application**	
	Aggregate (Kg/m^2)	**Binder (Kg/m^2)**
Coarse aggregate seal coat	12.5- 20.0	1 .00- 1.80
Medium aggregate seal coat	10.0-15.0	0.90- 1.80
Slurry seal	Between 5-6 Kg/m^2 for the mix	

B. The Engineer reserves the right to order additional trial sections and alter the previously established rates of application during progress of the Works.

4.06.06 CONSTRUCTION

A. General

A.1 Applications of bitumen and aggregate and subsequent rolling shall be completed between sunrise and sunset and under favourable weather conditions as determined by the Engineer. The atmospheric temperature shall be above 15 ^{o}C and the weather shall not be foggy, rainy, dusty or unduly windy.

A.2 Where the seal coat is to carry traffic prior to final sweeping, appropriate signs shall be erected to control the speed of traffic. Provision for traffic control shall be in accordance with the relevant requirements of Section 6 .07 - Maintenance of Traffic and Detours.

A.3 When bituminous coatings are applied to sections of road which are to be promptly opened to traffic and the ambient temperature is contributing to slow curing and excessive pickup, the Contractor shall suspend operations until the Engineer approves continuation of sealing works.

A.4 The surface to be treated shall be dry or slightly damp and the moisture content of aggregates at the time of application to the coated surface shall not exceed 3% by weight.

A.5 Unless otherwise directed by the Engineer, the minimum time interval between successive seal coats, in DBSD applications, shall be 5 days.

B. Surface Preparation

B.1 Granular surfaces shall be primed in accordance with the requirements of Section 4.02 - Bituminous Prime and Tack Coats prior to construction of the surface treatment. If there are delays in scheduling the seal coating resulting in deterioration of the surface, the Engineer shall inspect the affected area and order appropriate repairs or corrective treatment prior to the commencement of the seal coat application.

B.2 When coatings are applied to existing pavement surfaces, all pavement repairs shown on the Drawings or instructed by the Engineer shall first be completed. Where applicable, the positions of traffic markings shall be surveyed and recorded to enable their accurate replacement after the seal coats have been applied.

B.3 Immediately before applying any bituminous material, all dirt, dust and other objectionable material shall be removed from the surface and cracks shall be repaired or sealed as directed by the Engineer. If required, the surface shall be slightly dampened with a light application of water immediately prior to the application of bitumen.

B.4 Surfaces to be slurry sealed shall be lightly sprayed immediately prior to spreading the slurry with a slow-curing 3:1 water: emulsion mixture applied at the rate of 0.4 - 0.8 Kg/ m^2

C. Heating of Bitumen

The temperature of cutback bitumen and of emulsified bitumen at the time of application shall be as specified in Section 4.01 - Materials for Bituminous Construction.

D. Spreading Slurry Seal

D.1 Spreading of slurry seals shall be by a spreader box approved by the Engineer, capable of spreading over at least one traffic lane width. It shall have flexible rubber strips fastened on each side to prevent loss of slurry and shall have baffles incorporated into the box to ensure a uniform application. A rear flexible, adjustable strike-off blade shall also be provided.

D.2 Areas inaccessible to the slurry spreader box shall be slurry scaled using hand or other methods approved by the Engineer.

D.3 The slurry seal coat shall be uniform and homogeneous after spreading and shall not show signs of separation of the emulsion and aggregate after setting.

E. Spraying of Bitumen

E.1 The cutback or emulsified bitumen for seal coats shall be applied by means of a pressure distributor uniformly and continuously over the section to be treated. The rate of application shall be as shown on the Drawings or as designated by the Engineer.

E.2 A strip of building paper or heavy polyethylene sheeting, at least one metre in width and with a length equal to that of the spray bar of the distributor plus 300 mm shall be used at the beginning of each application. If the cut-off is not positive, the paper shall be used at the end of each spread. The paper shall be removed and disposed of after use. The distributor shall move forward at the correct application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected immediately as directed by the Engineer.

E.3 The length of spray run shall not exceed that which can be covered by the aggregate spreading equipment.

E.4 The application width of bitumen shall be not more than 150 mm wider than the width covered by the aggregate spreader. Operations shall not proceed if the bitumen is allowed to chill, dry or otherwise impair retention of the aggregate.

E.5 The Contractor shall keep a complete record of bitumen used based on distributor tank measurements and on areas to which the bitumen has been applied. These records shall be submitted to the Engineer as verification of the accuracy of the tachometer and application rates designated by the Engineer.

E.6 Distribution of bitumen shall be regulated and sufficient material left in the distributor at the end of each application to ensure a uniform distribution across the spray bar. The distributor shall not expel air with the bitumen causing uneven coverage.

E.7 The angle of the spray nozzles and the height of the spray bar shall be adjusted and regularly checked to ensure uniform distribution. The height of the spray bar above the pavement surface should remain constant throughout the spraying process. Distribution shall cease immediately upon any clogging or partial blocking of any nozzle and corrective measures shall be taken before application is resumed.

F. Application of Aggregate

F.1 If directed by the Engineer, aggregates shall be washed prior to use in order to eliminate or reduce any dust coatings or salts before delivery to the spreader.

F.2 Operation of the aggregate spreader at speeds which cause the particles to roll over after striking the bitumen covered surface shall not be permitted.

F.3 Immediately upon application of bitumen, aggregate of the required gradation shall be spread at the rate designated by the Engineer. Spreading shall be accomplished in such a manner that the tyres of the hauling unit or aggregate spreader do not come into contact with the uncovered bitumen surface.

F.4 Where adjacent applications are to be made, the first aggregate application shall not extend closer than 150 mm to the edge of the applied bitumen. The adjacent application of bitumen shall overlap this 150 mm and complete aggregate coverage shall be achieved with the second application.

F.5 Immediately after the aggregate has been applied, deficient areas shall be covered by additional aggregate. Piles, ridges or uneven distributions of aggregate shall be removed and corrected to avoid permanent ridges, bumps or depressions in the completed surface. Additional aggregate shall be carefully spread to prevent pick-up by rollers or traffic; after which the surface shall be rolled as directed by the Engineer.

F.6 The Contractor shall take measures to prevent aggregate from entering ditches or inlets of any type. The Contractor shall be responsible for removal of any such aggregate materials and other accumulated debris arising out of his operations.

G. Rolling and Brooming

G.1 Aggregate shall not be spread more than 150 metres ahead of initial rolling operations.

G.2 Rollers shall not stop, start or turn on the surface being rolled. Any damage to the surface arising out of non-compliance with this requirement shall be made good as directed by the Engineer and at the Contractor's expense.

G.3 Initial breakdown rolling shall proceed behind the spreader (after any adjustments by hand methods to correct for uneven distribution). One complete coverage shall be achieved using 2-axle self-propelled steel-wheeled rollers of 6-8 tons weight and operating at a

maximum speed of 5 km/h. Initial rolling shall be completed within 30 minutes of spreading aggregate.

G.4 The Engineer shall order the use of pneumatic-tyred rollers for initial rolling if the achievement of adequate embedment of the aggregate is liable to result in excessive crushing when steel-wheeled rollers are used.

G.5 Immediately following completion of the initial rolling, the surface shall be rolled using self-propelled pneumatic-tyred rollers operated at a maximum speed of 8 Km/h, until at least 3 complete coverages have been achieved.

G.6 If necessary during rolling operations, additional screenings shall be lightly spread by hand methods and re-rolled to make good any small areas visibly deficient in cover material.

G.7 Light drag brooming of the surface shall be carried out 24 hours after completion of rolling to embed aggregate particles. Brooming shall result in a uniform distribution of loose screenings over the surface which shall then be re-rolled using pneumatic-tyred rollers until at least 2 complete coverages have been achieved.

G.8 Light drag brooming and re-rolling shall be repeated 24 hours after the initial brooming, if so directed by the Engineer.

G.9 Excess (surplus) screenings shall be collected and stockpiled or disposed of as directed by the Engineer.

H. Maintenance and Protection of Sealed Surfaces

H.1 BSSC shall be protected from traffic until such time as, in the opinion of the Engineer, the coatings have cured sufficiently and will not be damaged by, adhere to or be picked up by the tyres of vehicles.

H.2 Each coat of SBSD and DBSD shall be maintained and protected from excess traffic speeds for at least 3 days after completion of rolling.

H.3 At the end of the 3-day maintenance period for each seal coat, or earlier if directed by the Engineer, the surface shall be finally swept using a rotary broom to remove loose screenings. Surplus screenings shall be stockpiled or disposed of as directed by the Engineer.

H.4 Adequate traffic control (including speed control measures) shall be taken during the construction of bituminous seal coats and surface dressings in accordance with the relevant requirements of Section 6.07 - Maintenance of Traffic and Detours.

4.06.07 TOLERANCES AND RECORDS

A. The Contractor shall be responsible for the accurate calibration of pressure distributors and for the correct rates of application of bitumen as designated by the Engineer.

B. Readings shall be taken of the volume and temperature of each bitumen tanker load and temperature immediately prior to and immediately upon completion of each spraying run and the actual application rate in kg/m^2 shall be calculated. Complete records shall be maintained of all such measurements and the specific location, width and length of each the respective run.

C. The tolerances on temperature adjusted application rates of cutback bitumen shall be plus or minus 5% of the designated rate.

D. Applications of cutback bitumen varying by more than 5% but less than 10%, after temperature adjustment, below the specified rate of application shall, if the work is accepted by the Engineer, be subject to a 10% reduction in quantity or area measurements as appropriate.

E. Applications of cutback bitumen varying after temperature adjustment by more than 5% but less than 10% above the specified rate of application shall, if the work is accepted by the Engineer, be measured on the basis of the designated application rate.

F. Applications of cutback bitumen varying by more than 10%, after temperature adjustment, above or below the specified rate of application shall be rejected and the unsatisfactory material replaced or made good as directed by the Engineer, at the Contractor's expense.

G. The Contractor shall maintain on a daily basis complete records of the volumes and tonnages of each type of aggregate delivered to the Site and used in each section of the Works for seal coat and surface dressing applications.

H. All records and calculations of bitumen applications and aggregate delivery and use shall be submitted to the Engineer at the end of each day when seal coat and surface dressing applications have been carried out. No measurements will be accepted of bitumen applications which are not supported by adequate, verifiable records.

4.06.08 MEASUREMENT

The quantity of seal coats and surface dressings to be paid for shall be the number of square metres for each application as entered in the Bill of Quantities. No separate payment shall be made for bituminous material or cover aggregates.

SECTION 4.07 BITUMINOUS LEVELLING COURSE

4.07.1 SCOPE

The work covered in this section consists of furnishing materials, mixing at a central mixing plant, spreading and compacting bituminous wearing course on an existing pavement surface as and where shown on the Drawings or as directed by the Engineer.

4.07.2 MATERIALS

A. All materials shall conform to the relevant requirements of Section 4.01 - Materials for Bituminous Construction.

B. Unless otherwise shown on the Drawings, materials shall also conform to the requirements of Section 4.05 - Bituminous Wearing Course.

4.07.3 JOB MIX AND PROJECT MIX

A. The Job Mix Formula shall be established by the Contractor in accordance with the procedures and requirements of Section 4.03 - Bituminous Courses and Section 4.05 - Bituminous Wearing Course.

B. The Job Mix for bituminous levelling courses shall conform to the requirements of Section 4.05 - Bituminous Wearing Course.

4.07.4 EQUIPMENT

Plant and equipment for mixing, hauling, placing and compacting bituminous levelling course materials shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

4.07.5 CONSTRUCTION OF TRIAL SECTIONS

Trial Sections shall be constructed as and where directed by the Engineer and in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

4.07.6 SURFACE PREPARATION

A. Damaged pavement surfaces shall be repaired by patching prior to receiving the bituminous levelling course in accordance with the relevant requirements of Section 4.08: Pavement Repairs, Trench Excavation and Reinstatement Works The nature and extent of patching shall be as shown on the Drawings or as directed by the Engineer.

B. In areas where levelling courses are required, either as shown on the Drawings or as directed by the Engineer, the Contractor shall take cross sections of the existing pavement after completing any patching. The cross sections shall be taken at intervals of 10 metres or as directed by the Engineer. When the survey has been approved, the Engineer shall determine and inform the Contractor of the locations, grades and thicknesses of levelling courses required to obtain the desired surface.

C. Prior to placing levelling courses the existing pavement surface shall be prepared in accordance with the relevant requirements of Section 4.03 - Bituminous Courses, including the use of prime and tack coats as appropriate.

4.07.7 DELIVERY, SPREADING AND FINISHING

A. The delivery, spreading and finishing of levelling courses, including compaction, shall conform to the relevant requirements of Section 4.05 - Bituminous Wearing Course.

B. In areas where a specific grade and superelevation are to be achieved by the levelling courses, setting out and level control shall be based on a reference line installed in accordance with the relevant requirements of Section 4.03 - Bituminous Courses. In areas of minor levelling such as filling of potholes or small isolated areas, a mobile reference line or alternative control system may be approved by the Engineer.

4.07.8 SAMPLING AND TESTING

A. Sampling and testing of levelling courses shall conform to the relevant requirements of Section 4.03 - Bituminous Courses.

B. Where sampling and testing are not feasible due to thickness or other constraints, the Engineer shall determine specification compliance based on an approved rolling pattern or another method.

4.07.9 SURFACE TOLERANCES

Surface Tolerances for levelling courses shall conform to the relevant requirements for Binder Courses in Section 4.04 - Bituminous Base Course.

4.07.10 DETERMINATION OF THICKNESS

The Engineer shall use thickness measurements, spread rates, cross section or other methods as appropriate to verify quantities placed. Thickness measurements shall be in accordance with the relevant requirements of Section 4.03 - Bituminous Courses.

4.07.11 MEASUREMENT

A. Bituminous levelling courses shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thicknesses shown on the Drawings or as otherwise directed by the Engineer.

B. Patching shall be measured by the cubic metre of mix furnished, spread, compacted, completed and accepted. Measurements shall be based on the areas and thicknesses shown on the Drawings or as directed by the Engineer.

C. Bituminous Tack Coat shall not be measured or paid for separately but the costs shall be deemed to be included in associated rates and items.

D. All other incidental items shall not be measured for direct payment, as prescribed in Section 4.03 - "Bituminous Courses".

SECTION 4.08: PAVEMENT REPAIRS, TRENCH EXCAVATION AND RESTATEMENT WORKS

4.08.1 SCOPE

A. The work covered in this section consists of repairs to damaged or defective pavement and the excavation and reinstatement of road openings on existing highways, streets and footpaths as and where shown on the Drawings or as directed by the Engineer.

B. Repairs to existing pavement include:

- Pothole repairs and patching
- Crack sealing
- Removal and replacement of defective pavement layers

C. Road openings include: -

- The breaking up or opening up of a street or other highway for the purpose of: -
  i). Laying, repairing, adjusting, altering or removing any utility or apparatus, or
  ii). Examining subsoil conditions or any existing utility or apparatus:
- Any work which is preparatory or incidental to any works referred to in the paragraphs above, such as the temporary storage of deposition of any building materials, debris, temporary foundation or the placing of any equipment.

4.08.2 MATERIALS

A. All pavement materials shall conform to the relevant requirements of Section 3.01 – Materials for Sub-Base and Base Courses and Section 4.01 –Materials for Bituminous Construction.

Subgrade materials shall conform to the relevant requirements of Section 2.07 – Subgrade Construction.

4.08.3 EQUIPMENT

All plant and equipment shall conform to the relevant requirements of Part 1 of the Specifications, Section 4-4 – Contractor's Plant and Equipment

4. 08.4 GENERAL REQUIREMENTS

A. Full Time Site Supervisor

The Contractor shall nominate from his site staff a full – time site supervisor responsible for road openings and reinstatement works, who shall be contactable by the Engineer and all other affected parties at all times during the period of the reinstatement works including the duration of traffic management. The supervisor shall be capable of responding to any emergency or other situation that arises as a consequence of the rehabilitation and reinstatement work and shall be the Contractor's first point of contact on safety issues arising out of these works.

B. Position, Extent and Protection of Excavation

The Contractor shall take the following into account when preparing method statements for road openings:-

- The extent of road opening at any one time shall not exceed 60 metres in length
- The occupation of a carriageway for road opening shall be restricted to one traffic lane width.
- Measures to protect the nearby road surface, existing structures, apparatus and road- related facilities during the course of the road opening and reinstatement work
- A maximum of two trial holes shall be permitted at any one time. No additional trial holes shall be opened until the existing trial holes are properly reinstated to the satisfaction of the Engineer.
- The road surface shall be protected from damage from construction vehicles. Any damage to the surrounding road surface shall be made good to the satisfaction of the Engineer at the Contractor's expense

4.08.5 PREPARATION OF PAVEMENT

A Cracks in bituminous pavement which, in the opinion of the Engineer, do not require reconstruction shall be prepared by wire brushing and blowing out with compressed air.

B Defective bituminous pavement which, in the opinion of the Engineer, requires reconstruction shall be cut back to good material using pneumatic cutting tools. The cut edges shall be square or rectangular and in line with the direction of traffic. The depth of cut shall be determined by the Engineer and may include asphalt layers, base and sub – base layers and subgrade layers (in the case of failed pavement, excavation shall include a minimum of 300 mm of subgrade material). All excavated materials shall be removed and disposed of off site. When the bottom of the excavation consists of earth or granular material, it shall be thoroughly compacted using mechanical compactors to the satisfaction of the Engineer. Excavated bituminous surfaces shall be thoroughly cleaned and wire brushed prior to receiving repair materials.

C Utility trench reinstatements in bituminous pavements shall be prepared in the same way as defective bituminous pavement. Excavation shall include a minimum of 300 mm of subgrade material.

4.08.6 PLACING AND FINISHING REPAIR MATERIALS

A Cracks less than 3 mm wide shall be saturated with a 1:1 diluted emulsified bitumen unless otherwise directed by the Engineer. Cracks shall be filled to the road surface level. Any excess bitumen shall be removed with a squeegee and the bitumen surface shall be sprinkled liberally with coarse sand.

B Cracks of 3 mm width or more shall be filled with clean, coarse sand and then saturated with a 1:1 diluted emulsified bitumen or as directed by the Engineer. Cracks shall be filled to the road surface level. Any excess bitumen shall be removed with a squeegee and the bitumen surface shall be sprinkled liberally with coarse sand.

C Excavations below subgrade level shall be filled to a level specified by the Engineer with subgrade material in layers not exceeding 150 mm and compacted using mechanical compactors to conform to the requirements of Section 2.07 – Subgrade Construction and to the satisfaction of the Engineer.

D Sub-base and/or base course, if required, shall be placed in layers not exceeding 150 mm and compacted using mechanical compactors. They shall conform to the relevant requirements of Section 3.02 – Granular Sub – Base Courses or Section 3.03 –Aggregate Base Courses and shall be to the grading shown on the Drawings or as specified by the Engineer.

E Prior to receiving bituminous material the excavations shall be thoroughly cleaned. Subgrade, sub-base or base course material shall be primed with a light coating of MC cutback or emulsified bitumen and existing bitumen surfaces shall be lightly painted with emulsified bitumen, all in accordance with the requirements of Section 4.02 – Bituminous Prime and Tack Coats.

F The excavation shall be filled with bituminous pavement materials placed in layers not exceeding 70 mm and compacted using vibratory compactors. Unless otherwise ordered by the Engineer, the top layer shall be compacted by a steel wheeled roller, by first compacting the 150 mm strips adjacent to the traffic edges and then rolling in the direction of traffic. Bituminous materials shall conform to the relevant requirements of Section 4.04 – Bituminous Base Course and Section 4.05 –Bituminous Wearing Course and shall be to the gradings shown on the Drawings or as specified by the Engineer.

G New utility trenches shall be backfilled to the details shown on the Drawings or as instructed by the Engineer and may include surround, haunching or protective materials. Construction of subgrade and pavement shall be as for pavement repairs.

H No excavated areas shall remain open overnight.

4.08.7 ADDITIONAL REQUIREMENTS FOR REPAIRS TO EXISTING PAVEMENT

A Work Programme/ Schedule

A Work Programme / Schedule shall be submitted to the Engineer for approval prior to the start of repair work. The programme may be in the form of bar/ Gantt charts that indicate the areas of work and show the extent and duration of works and the sequence of partial road closures.

B Temporary Traffic Management Proposals

The proposed traffic control plans for the various stages of work that affects traffic, including pedestrians, shall be submitted. The plans shall include temporary signing details and forms of traffic control to be used. The proposed plans shall comply with the requirements of the Health, Safety and Environmental Regulations in Volume 1 and current LIBNOR Standards.

4.08.8 ADDITIONAL REQUIREMENTS FOR ROAD OPENINGS

A Duties and Responsibilities – Road Opening

The Contractor shall be responsible for coordination with the relevant service provider. All trench reinstatement works shall be performed in accordance with these specifications and the regulations of the relevant service provider

B Application for Road Opening

The Contractor shall submit written proposals to the Engineer for approval prior to carrying out road opening works. The application shall comply with the requirements of the Health, Safety and Environmental Regulations in Volume 1 and current LIBNOR Standards and include the following:

Detailed Plans

Plans showing details of the opening work including the following: -

- Location of road opening
- Existing and proposed manhole positions
- Lines and levels of other services that may be affected by the works
- Position of trees and road facilities
- Existing road lines and other road markings

Photographs

Photographs of existing conditions.

Temporary Traffic Management Proposals

The proposed traffic control plans for the various stages of opening that affect traffic, including pedestrians. The plans shall include temporary signing details and, if necessary, forms of traffic control to be used.

Work Programme/ Schedule

A Work Programme / Schedule shall be submitted to the Engineer prior to commencement of road opening works. The programme may be in the form of bar/ Gantt charts that indicate the different stages of openings and show the duration of works and the extent of road affected.

Statutory Authority Approval

Written confirmation from the relevant service provider that the proposed crossing has been checked and approved.

4.08.9 SAMPLING AND TESTING

Testing of repair materials shall conform to the relevant requirements of Section 2.07 – Subgrade Construction, Section 3.02 – Granular Sub – Base Courses, Section 3.03 –Aggregate Base Courses and Section 4.03 – Bituminous Courses. Sampling shall be as ordered by the Engineer.

4.08.10 SURFACE TOLERANCES

A Levels shall be checked by straight edge in relation to the adjacent existing pavement.

B Surface tolerances for bituminous layers shall conform to the relevant requirements of Section 4.04 – Bituminous Base Course and Section 4.05 –Bituminous Wearing Course.

C Any deficiency in the wearing course surface shall be corrected by cutting out and replacing.

4.08.11 MEASUREMENT

Sealing of cracks shall not be measured for direct payment unless otherwise specified in the Contract Documents.

Pavement repairs shall be measured by the square metre of repair, prepared, filled, compacted, completed and accepted. Measurement shall be of the areas shown on the Drawings or ordered by the Engineer.

Trench reinstatements shall be measured by the square metre of reinstatement prepared, filled, compacted, completed and accepted by the Engineer. Measurements shall be of the areas shown on the Drawings or ordered by the Engineer.

No separate payments shall be made for excavation, prime or tack coats or pavement materials

All other incidental items shall not be measured for direct payment but shall be considered as subsidiary works, the costs of which will be deemed to be included in the Contract prices for the pay items.

SECTION 4.09 ROAD PLANING AND GRINDING

4.09.01 SCOPE

The work covered in this Section includes cold planing, including milling, of the existing asphalt pavement and grinding of concrete pavement and surfaces of structures to a specified depth at the locations shown on the Drawings or as directed by the Engineer in order to obtain the required levels and grades and to prepare the surface for receiving the subsequent asphalt overlay or to improve the skid resistance of the existing surface. The Contractor shall be responsible for all traffic management during the execution of the works.

4.09.02 EQUIPMENT

A. All plant and equipment shall conform to the relevant requirements of Part 1 of the Specifications, Section 4-4 – Contractor's Plant and Equipment and the following

B. Planing shall be carried out using a purpose built machine capable of planing to the specified depth and within the tolerances stated in this section.

C. Grinding shall be performed with abrasive grinding equipment with diamond cutting blades.

4.09.03 ROAD PLANING ANG GRINDING OPERATIONS

A. Except on structures, the entire area of pavement in locations designated on the Drawings or as directed by the Engineer shall be planed or ground to the depth as detailed.

B. Ground surfaces shall not be smooth or polished and shall have a coefficient of friction of not less than 0.30.

C. Planing of Asphalt Surfaces

C.1 Existing asphalt pavement shall be planed to the depth specified on the Drawings or instructed by the Engineer so that the finished surface shall not vary from a true plane to allow a 3 mm thick shim 80 mm wide to pass under a straightedge 3m long laid parallel to the centreline. The transverse slope of the finished surface shall not allow a 6mm thick shim 80mm wide will to pass under a straightedge 3 metres long.

C.2 Residue from planing asphalt pavement shall be disposed of or recycled in accordance with Section 4.12, Recycling of Pavement Materials, as detailed in the Drawings or as approved or instructed by the Engineer.

D. Grinding of Concrete Surfaces

D.1 Existing concrete pavement shall be ground so that the pavement surface on both sides of all transverse joints and cracks has essentially the same depth of texture and does not vary from a true plane enough to permit a 2 mm thick shim 80 mm wide to pass under a 1metre straight-edge adjacent to either side of the joint or crack when the straightedge is laid on the pavement parallel to centreline with its midpoint on the joint or crack. After completion of grinding the pavement shall conform to the straightedge and profile requirements specified in 4.3.10 of Specification Section 4.03.

D.2. Areas identified by or agreed with the Engineer as abnormally depressed due to subsidence or other localized causes shall be excluded from testing with the straightedge, if the accumulated total of all such excluded areas does not exceed 5 percent of the total area to be ground. Straightedge testing shall end 10 metres prior to such excluded areas and shall resume 10 metres following.

D.3 The noise level created by the combined grinding operation shall not exceed 86 dBA at a distance of 15 metres at right angles to the direction of travel.

D.4 Ground areas on structures, approach slabs and the adjacent 15 metres of approach pavement shall conform to the requirements for smoothness and concrete cover over reinforcing steel specified in Part 5: Concrete Works.

D.5 Concrete removal and replacement operations shall not disturb the adjacent concrete pavement, base and subgrade. If such material is disturbed, concrete surfaces shall be made good to the satisfaction of the Engineer and base and subgrade recompacted to relative densities of not less than 100 and 95% respectively; all at the Contractor's expense.

D.6 Residue from grinding operations shall be collected using a vacuum attachment on the grinding machine and not left on the surface of the pavement.

D.7 Residue from grinding concrete pavement shall be disposed of as detailed in the Drawings or as instructed by the Engineer.

4.09.04 PREPARATION OF PLANED SURFACE FOR RESURFACING

A. When a new asphalt mix is to be placed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. Any loose, broken or shattered asphalt material along the edges of the existing surface shall be removed and the exposed unbound material and a sufficient width adjacent to the edge of the existing surface shall be shaped, bladed, compacted and broomed to provide a uniform firm subgrade base for the new surface course. Broken, soft or unstable areas of existing asphalt surface, base or subgrade shall be removed and replaced. The areas shall be excavated to a depth as directed and refilled with the specified asphalt mix. Any cracks encountered in the exposed bituminous surface, shall be prepared as specified in accordance with Parts 4.08.6A or B of Section 4.08: Trench Reinstatement and Pavement Repairs before laying the new asphalt layer.

B. When detailed on the Drawings or instructed by the Engineer, prior to placing of the

asphalt mix on an existing asphalt surface, a tack coat as specified in Section 4.02: Bituminous Prime and Tack Coats shall be applied to the existing surface at the rate determined by the Engineer. No mixture shall be laid on a tack coat until it has been inspected and approved by the Engineer.

C. When the asphalt mix is to be placed on an existing aggregate base course surface, the surface shall be recompacted to 100% maximum dry density (AASHTO Modified Proctor).

D. In locations where the aggregate base course consists of gap-graded aggregate and contains excess fines or moisture or does not comply with the specified base course material quality and cannot be compacted to the above required density: then it shall be replaced to a depth of 150 mm with suitable aggregate base course material in order to meet the Specifications and the Engineer's approval.

E. Prior to placing of the asphalt mix on an existing or replaced aggregate base course, a prime coat as specified in Section 4.02: Bituminous Prime and Tack Coat shall be applied to the surface at the rate determined by the Engineer. No mixture shall be laid on a prime coat until it has been inspected and approved by the Engineer.

4.09.05 MEASUREMENT

A. Planing of the existing asphalt shall be measured by the square metre of the planed area to the specified depth. No additional payment shall be made for planing to a greater depth or area than specified. All surface preparation and cleaning works specified above shall be deemed included in this pay item.

B. Refilling the planed or ground area with bituminous wearing course shall be paid separately to the specified depth in accordance with Section 4.05: Bituminous Wearing Course or Section 4.04 Bituminous Base Course as appropriate.

C. Prime coat under the new bituminous layers shall also be paid separately as specified under Section 4.02: Bituminous Prime and Tack Coats.

D. Pavement grinding shall be measured by the square metre. The quantity of pavement grinding to be measured for payment will be determined by multiplying the width of the area ground by the length ground. No additional payment shall be made for grinding to a greater depth or area than specified. All surface preparation and cleaning works specified above shall be deemed included in this pay item.

E. The Contract price paid per square metre for planing and grinding existing surfaces shall include full compensation for furnishing all labour, materials, tools, equipment, and incidentals and for all work involved in planing or grinding the existing pavement and removing and disposing of residue, including furnishing water for washing the pavement, as shown on the Drawings, as specified in these specifications and as directed by the Engineer.

SECTION 5: CONCRETE AND STRUCTURES

SECTION 5: CONCRETE AND STRUCTURES

SECTION 5.01 CONCRETE MIXES AND TESTING

5.01.1 SCOPE

The works covered in this Section consists of the specifications for concrete materials including sampling, testing and storage of such materials, concrete strength requirements, concrete testing procedures and requirements and job mixes.

5.01.2 MATERIALS

A. Cement

A.1 Cement shall be Portland cement, originating from manufacturers approved by the Engineer and shall comply with BS EN 197-1:2000 for Ordinary Portland Cement and with BS 4027:1996 for Sulphate Resisting Portland Cement.

A.2 Only one type or brand of cement shall be used in any one structural member. Mixing of types or brands shall not be permitted.

A.3 All cement shall be subject to approval and shipments of cement shall be accompanied by a manufacturer's Certificate of Guarantee and a laboratory test certificate. Approval of any cement sample shall not relieve the Contractor of the responsibility to fabricate concrete of the specified quality and strength.

A.4 When factory or field tests subsequent to original approval tests show that the cement no longer complies with the Specifications, the entire consignment from which the sample was taken shall be rejected and the Contractor shall immediately remove the rejected material from the Site and replace it with cement meeting the required specifications.

A.5 Whenever low alkali cement is specified, the total alkali content, expressed as the sodium oxide equivalent, shall not exceed 0.6% by weight. Approval of any cement sample shall not relieve the Contractor of the responsibility to fabricate concrete of the specified quality and strength.

A.6 If local test certificates are not available the Contractor shall obtain from each proposed manufacturer a typical sample of cement which shall be fully and independently tested in accordance with the appropriate standard and the results submitted for approval. Primary and secondary sources of the required cement shall be given. All costs associated with the testing shall be allowed for by the Contractor.

A.7 Details shall also be submitted of the manufacturer's name, the address of the source of production, the manufacturer's description of the cement type and brand name and the standards to which compliance is guaranteed.

A.8 Average values and corresponding maximum and minimum values of the following cement composition and properties shall be submitted, covering a continuous production period of at least 6 months and ending not earlier than 3 months before submission of the data. The Contractor shall state if any material or production process changes have been made since the end of the above period; if any are proposed details shall be provided.

Composition	**Properties**	
Insoluble residue	Lime saturation factor (LSF)	
Silica (SIO_2)	Alumina-iron ratio (A/F)	
Alumina (AL_20_3)	Tri-calcium aluminate (Ca3A1)	
Total Iron ($Fe_2 O_3$)	Free lime in clinker (as CaO)	
Calcium (CaO)	Total acid solution alkalis	
Magnesium (MgO)	Heat of hydration	
Potassium ($K_2 O$)	- at 7 days	
Sodium (Na_2)	- at 28 days	
Sulphate (SO_3)	Fineness (m^2./kg)	
Sulphur (S)	Setting times	- Initial (min)
Chloride (Cl)		- Final (min)
Loss on ignition	Soundness (mm)	
	Compressive strength	- 3 days
		- 7 days
		- 28 days
		- 3 months

A.9 The requirements of item A.8 shall only be modified or dispensed with at the discretion of the Engineer and if such dispensation is given in writing.

A.10 The manufacturer's bulk average test certificate for each consignment of cement shall be submitted, showing the results for chemical composition and physical properties determined in accordance with the relevant standard. Samples shall be taken for each consignment of cement and tested as directed by the Engineer by an approved independent laboratory and at the Contractor’s expense.

A.11 Where bulk cement deliveries are proposed, the Contractor shall provide all information required by the Engineer concerning off-site storage and loading arrangements and facilities for the Engineer to inspect these arrangements for approval purposes shall be provided. Consignments shall be used in the order in which they are delivered.

A.12 Storage capacity shall be sufficient to meet the schedule of work so that continuous work is achieved. Cement shall be stored in moisture-proof storage sheds. Stale, caked, reclaimed or re-sacked cement shall not be used. The Contractor shall not store cement in areas subject to flooding.

A.13 Cement remaining in bulk storage at the mill for more than 6 months or cement stored in bags in local storage by the Contractor or a vendor for more than 3 months after shipment from the mill shall be retested before use and shall be rejected if it fails to meet any of the requirements of these specifications.

B. Aggregates

B.1 Proposed aggregate sources shall be examined by the Engineer who shall check the following:

- Name, location, grid reference, type of deposit, potential variability, methods of extraction.
- Methods and degree of control exercised over extraction.
- Processing methods, types of plant, number of processing stages, standards of maintenance and process control, producer's laboratory facilities and technical staffing.
- Stockpiling arrangements, loading and supply arrangements.
- Potential variations in end-products due to variations inherent in the deposit and in the existing methods of extraction, processing and stockpiling.
- Modifications to existing extraction, processing, storage and handling arrangements, and to supervision arrangements to reduce end-product variations.
- Requirements for supplementary processing on site.

B.2 The Contractor shall provide photographs of each of the proposed new sources and related production arrangements. The source photographs shall include low level aerial photographs and close-ups of working faces.

B.3 Aggregate deposits shall be sampled and tested in a systematic manner to assess their potential variability and to assist in determining appropriate methods of extraction and processing.

B.4 The deposit investigation and sampling programmes shall be relevant to each type of deposit and shall be devised and supervised by an experienced engineering geologist approved by the Engineer. The engineering geologist shall make a field reconnaissance of the potential deposit areas and the existing workings.

B.5 Each size of aggregate shall be sampled at the discharge points on the production plant (i.e. conveyors or hoppers, not stockpiles) at three well spaced intervals during the course of each of three consecutive production days; these samples shall be designated "production samples".

B.6 Samples shall be taken from producer's stockpiles of any materials with visible variations in physical characteristics or appearance and materials ready for loading. These samples shall be designated "stockpile samples".

B.7 All samples shall be taken by arrangement with and in the presence of the Engineer or his representative and shall be tested in accordance with these specifications

B.8 All samples shall split for independent testing by the Contractor and the Engineer. These samples shall be retained on site.

C. Testing Aggregates

C.1 Each production sample shall be tested for the following:

- Proportion of natural (uncrushed) material (% by weight) passing a 75mm sieve.
- Total acid soluble chloride content and total acid soluble sulphate content (% by weight).
- Flakiness and elongation indices.

C.2 Aggregates from all production sources shall be combined (by equal weight) to form composite production samples for each size of aggregate. The composite samples and the individual production samples shall be tested for the following: -

- Potential Reactivity tests for alkali-silicate and alkali-carbonate reactions: petrographic examination in accordance with BS 812-104:1994 or ASTM C295, rapid chemical method in accordance with ASTM C289 and rock expansion test in accordance with ASTM C586. If one or more of these tests are positive then the mortar prism test in accordance with ASTM C227 shall be carried out.
- Partial chemical analysis, including insoluble residue (ASTM D3042-84), chloride content, sulphate content and calculated approximate composition.
- ASTM Soundness Test C88, using a sodium sulphate solution, or ASTM Soundness Test C88, using a magnesium sulphate solution.
- Aggregate Impact Value by the Los Angeles test in accordance with BS EN 1097-2:1998 or AASHTO T96-83, ASTM C131-81 and ASTM C535-81.
- 10% Fines Value to BS EN 1097-2:1998 or BS 812-111:1990.
- Aggregate Abrasion Value to BS EN 1097-8:2000.
- Specific Gravities and Water Absorption to BS EN 1097-3:1998 or BS 812-2:1995.

C.3 Stockpile samples shall be examined and tested at frequencies determined by the Engineer.

C.4 The properties of the aggregates shall be such that the Drying Shrinkage of concrete prepared and tested in an approved laboratory in accordance with the United Kingdom Building Research Station Digest No. 35 (Second Series) shall not exceed 0.045 percent. The Initial Drying Shrinkage of all the proposed concrete mixes prepared and tested in an approved laboratory in accordance with BS EN 1367-4: 1988 shall not exceed 0.06 percent.

C.5 Aggregate for use in concrete or mortar that will be subject to wetting, exposure to a humid atmosphere or in contact with moist ground shall also be subject to the following conditions: -

- Aggregate shall not contain material that is deleteriously reactive with the alkalis in the cement or is present in the aggregates and mixing water or water in contact with the concrete, in amounts sufficient to cause excessive localized or general expansion of concrete or mortar.
- Dacite, Andesite, Rhyolites, Opal Cherts or Tuffs shall not be used in aggregates.
- Coarse and fine aggregates shall be tested for reactivity potential and shall satisfy the criteria given for innocuous aggregates in ASTM C 1260. The period of testing shall be a minimum of 26 weeks unless otherwise agreed by the Engineer.

D. Fine Aggregates

D.1 Fine concrete aggregates shall conform to AASHTO M6 and shall consist of natural sand or crushed rock having hard and durable particles or, if approved by the Engineer, other inert materials having similar characteristics. 100% of the fine aggregate shall pass the 9.5 mm sieve and 2% to 10% shall pass the 0.15 mm sieve. The fine aggregate shall not contain harmful materials including iron pyrites, coal, mica, shale or similar laminated materials, flat or elongated particles or any materials which may adversely affect the reinforcement or the strength, durability and texture of the concrete.

D.2 The Contractor shall wash the fine aggregates to remove deleterious substances or for colour consistency. Washing shall be carried out using fresh water. The water shall be replaced regularly to minimise the chloride and/or sulphate content.

D.3 The total acid soluble sulphate content (BS EN 1744-1:1998 or BS 812-118 1988) of fine aggregate, expressed as sulphur trioxide (SO_3), shall not exceed 0.40% by dry weight (BS EN 1744-1:1998 or BS 812-117:1988). The total acid soluble chloride content, expressed as sodium chloride (NaCl), shall not exceed 0.10% by dry weight of fine aggregate. The following additional requirements shall apply to the concrete mix:

- Total sulphate content (as SO_3) of any mix, excluding that present in the cement but including any present in the other materials, shall not exceed 2.5% by weight of cement in the mix.
- Total chloride content (as NaCl) of any mix, including any chloride present in the other materials and in the mix water, shall not exceed 0.35% by weight of cement in the mix.

D.4 Fine aggregate shall meet the following additional requirements:

- Fineness modulus, AASHTO M6: ±0.20% of approved value which shall be not greater than 3.1 or less than 2.3. Sieve analysis to AASHTO T27.
- Sodium or magnesium sulphate soundness AASHTO T104: max 12%, 18% loss respectively.
- Content of clay lumps and friable particles, AASHTO T112-82: 3% max.
- Sand equivalent AASHTO T176: min 75%.
- Coal and lignite, AASHTO T113-82: 0.5% Max.
- Organic impurities AASHTO T21-81: not darker than standard colour.

D.5 The amount of hollow shells likely to form voids and present in material retained on a 2.36 mm sieve determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

D.6 When sampled and tested in accordance with the appropriate sections of BS 812 (using test sieves in accordance with BS 410-1:2000 and 410-2:2000) the grading of fine aggregates shall be within the limits of the grading zones given in BS-EN 12620:2002. The fine aggregate shall be described as a fine aggregate of the grading zone into which it falls.

D.7 If the fineness modulus varies by more than 0.2 from the value assumed in the concrete mix design, the use of such fine aggregate shall be discontinued until suitable adjustments can be made to the mix proportions to compensate for the difference in gradation.

E. Coarse Aggregates

E.1 Coarse concrete aggregates shall conform to AASHTO M80 and shall consist of gravel, crushed gravel or crushed stone free from coatings of clay or other deleterious substances. It shall not contain harmful materials which can attack the reinforcement or adversely affect the strength and durability of the concrete. Coarse aggregate shall be washed to remove deleterious substances or for consistency of colour in the concrete.

E.2 The total acid soluble sulphate content (BS EN 1744-1: 1998) of coarse aggregate expressed as sulphur trioxide (SO_3) shall not exceed 0.40% by weight. The total acid soluble chloride contents of coarse aggregates, expressed as sodium chloride (NaCl), shall not exceed 0.05% by weight. These limits are also subject to the following requirements:

- The total sulphate content (as SO_3) of any mix, excluding that present in the cement but including any present in the other materials, shall not exceed 2.5% by weight of cement in the mix.
- The total chloride content (as NaCl) of any mix, including any chloride present in the other materials and the mix water, shall not exceed 0.35% by weight of cement in the mix.

E.3 Coarse aggregate shall also meet the following requirements:

- Sodium or magnesium sulphate soundness AASHTO T104: 5 cycles: max 12%, 18% loss respectively.
- Abrasion: in accordance with AASHTO T96 Max 40% loss.
- Content of clay lumps and friable particles: AASHTO T112-81: max 1% by weight.
- Soft fragments and shale: AASHTO M80: max 5% by weight.
- Flakiness index: BS EN 933-3: 1997: 30% max.
- Elongation index, BS 812-105.2:1990: 30% max.
- Coal and Lignite: AASHTO T113-82: 0.5% max.

E.4 The grading of coarse aggregate shall comply with AASHTO M43.

E.5 The coarse concrete aggregate, when tested according to AASHTO T27, shall meet the following gradation requirements and shall be graded within the limits stated in Table 5.1.1.

TABLE 5.1.1: LIMITS OF GRADATION FOR COARSE AGGREGATES

AASHTO Sieve Size	mm	Percent Passing by Weight for					
		Grading I	Grading II	Grading III	Grading IV	Grading V	Grading VI
3'	75	100	-	-	-	-	-
2 1/2"	63	-	100	-	-	-	-
2"	50	90-95	95-100	100	-	-	-
1 1/2"	37.50	-	-	95-100	100	-	-
1"	25.0	30-65	35-70	-	95-100	100	-
3/4"	19.0	-	-	35-70	-	95-100	100
1/2"	12.5	10-30	10-30	-	25-60	-	90-100
3/8"	9.5	-	-	10-30	-	20-55	40-70
No. 4	4.75	0-5	0-5	0-5	0-10	0-10	0-15
No. 8	2.36	-	-	-	0-5	0-5	0-5
No. 200	0.075	0-1	0-1	0-1	0-1	0-1	0-1

E.6 The type of grading for coarse concrete aggregates shall depend on the maximum particle size, which shall be no larger than one-fifth (1/5) of the narrowest dimension between sides of forms, nor larger than two-thirds (2/3) of the minimum clear spacing between reinforcing bars, whichever is least.

E.7 Before batching, all types of coarse aggregate shall be separated into fractions having uniform gradings.

F. Combined Aggregates

F.1 Combined aggregate comprises of a mixture of coarse and fine aggregates. They shall be used only in proportions agreed with the Engineer.

F.2 Materials passing the No. 200 (0.075 mm) sieve shall not exceed 3% by weight of the combined aggregate.

F.3 The combined concrete aggregate gradation shall be as specified or as directed by the Engineer. Grading 7 of Table 5.1.2 shall be used for kerbs, handrails, parapets, posts and other similar sections or members with reinforcement spacing too close to permit proper placement and consolidation of the concrete.

F.4 Changes from one gradation to another shall not be made during the progress of work unless approved by the Engineer.

F.5 For the proportion of each fraction of coarse aggregate and for fine and coarse aggregate, the combined gradings in Table 5.1.2 shall be used for the mix proportion design.

TABLE 5.1.2: LIMITS OF GRADATION FOR COMBINED AGGREGATES

AASHTO Sieve Size	mm	Combined Aggregate Percent Passing by Weight for						
		Grading 1	Grading 2	Grading 3	Grading 4	Grading 5	Grading 6	Grading 7
3"	75	100	-	-	-	-	-	-
2 1/2"	63	88-95	100	-	-	-	-	-
2"	50	78-90	88-95	100	100	-	-	-
1 1/2"	37.50	66-81	74-86	80-92	93-98	100	-	-
1"	25.0	51-70	56-75	63-80	70-88	87-96	100	-
3/4"	19.0	43-62	47-67	52-72	60-79	73-86	80-96	100
1/2"	12.5	32-53	36-58	41-60	47-66	57-74	61-80	73-86
3/8"	9.5	27-48	30-53	36-54	40-60	48-68	52-72	61-79
No. 4	4.75	19-38	22-42	23-43	28-49	34-55	38-56	43-64
No. 8	2.36	9-27	10-29	12-30	16-36	24-40	25-41	26-46
No. 16	1.18	4-19	5-21	6-22	7-25	9-28	11-29	13-33
No. 30	0.600	3-15	4-17	4-19	5-21	7-23	8-24	10-28
No. 50	0.300	2-11	2-13	2-14	2-15	4-17	5-19	5-21
No.100	0.150	1-7	1-8	1-8	1-9	2-10	2-11	2-12
No.200	0.075	0-3	0-3	0-3	0-3	0-3	0-3	0-3

G. Site Storage of Aggregates

G.1 Adequate stocks of tested and approved aggregates shall be maintained on site and the capacity of the storage bins for each type and grading of aggregate shall be sufficient to hold the respective quantities required for the maximum amount of concrete which the Contractor is obliged or intends to pour in any continuous operation in one day. The maximum height of aggregate stockpiles shall be 1.50 metres. Different grades of aggregates shall be separated by concrete block walls.

G.2 Dense concrete or bituminous slabs shall be laid with sufficient falls to cover all aggregate stockpile areas or bins and shall extend to cover all surrounding areas where aggregates are likely to be discharged or handled. These areas shall be swept and kept clean at all times to ensure that the aggregates are not contaminated by the adjacent ground through trafficking or otherwise and shall be constructed with adequate drainage for surplus water.

G.3 Windbreaks shall be provided where aggregates might suffer excessive contamination from windblown materials. During periods of heavy rain the bins or stockpiles shall be covered by tarpaulins.

H. Rejection of Aggregates

H.1 The Engineer shall reject any stockpiled material that has an excess build-up of fines.

H.2 Aggregates suffering from segregation or contamination during processing, handling at source, transportation to the site, stockpiling, handling on site or otherwise not complying with the requirements of the Specification shall be rejected and removed promptly from site regardless of any prior approval of the source.

I. Washing and Processing Aggregate

The Contractor shall carry out on site supplementary processing or effective washing of coarse and fine aggregates as necessary to comply with all requirements of the Specification.

J. Water

J.1 All sources of water, whether for mixing or curing of concrete or compaction of backfill around the concrete structures shall be approved by the Engineer. If during construction water from a particular approved source becomes unsuitable for purpose, the Contractor shall provide satisfactory water from other approved sources.

J.2 Water shall be free from injurious quantities of oil, alkali, vegetable matter and salt. The water shall be reasonably clear and shall contain not more than one quarter (0.25) percent solids by weight. Water shall comply with the requirements of BS EN1008:2002. If the specific conductance is less than 1500 micro ohms per centimetre, the total solids content requirement shall be waived, if agreed with the Engineer.

J.3 Non-potable water shall only be used when potable water is not available and provided the impurities do not exceed the values given in Table 5.1.3.

J.4 The water used in the mix design shall be from a source approved by the Engineer for site use.

J.5 Water used concrete containing or in contact with aluminium fittings or fixtures shall not contain chloride ions.

TABLE 5.1.3: MAXIMUM PERMITTED IMPURITIES IN NON-POTABLE WATER

Impurity	Max. Concentration (ppm)	Method
Chloride as (Cl-) a) Prestressed concrete or concrete in bridge decks b) Other reinforced concrete - in a moist environment, or - containing aluminium anchorages or reinforcement, or - permanent galvanized metal formwork	500 1000	ASTM D512
Sulphates as SO_4	300	ASTM D516
Alkalis as $Na_2O+0.658\ K_2O$	600	AASHTO T-26
Total solids	5000	

K. Admixtures

K.1 The quantity and method of using admixtures shall be in accordance with the manufacturer's recommendations and in all cases shall be subject to the approval of the Engineer.

K.2 The Contractor shall provide the following information for the Engineer's approval:

- The quantity to be used in kilograms per kilogram of cement and in kilograms per cubic metre of concrete.
- The detrimental effects caused by adding a greater or lesser quantity in kilograms per cubic meter of concrete.
- The chemical name(s) of the main active ingredient(s).
- Whether the admixture leads to the entraining of air.

K.3 The Contractor shall demonstrate the suitability of an admixture by means of trial mixes.

K.4 The use of calcium chloride in any form is prohibited.

L. High Workability Admixtures

L.1 Superplasticising agents shall be used when detailed on the Drawings or directed by the Engineer. The superplasticiser shall be stored and used strictly in accordance with the manufacturer's instructions and shall be fully compatible with all proposed concrete mix constituents. The optimum dosage of the additive shall be determined by site and laboratory trials to the Engineer's approval. The Contractor shall submit to the Engineer full details of his proposed mix design, which shall ensure that the minimum strength requirements as specified for the particular use of the concrete are achieved. Only when the Engineer has approved the proposed mix design shall such a mix be used in the Works.

L.2 The Contractor's mixing and transporting plant shall include accurate metering equipment for the measurement of superplasticising agents so that additives may be introduced immediately before placing.

L.3 The Contractor's rates for concrete listed in the Bill of Quantities shall include for the use of superplasticisers. The rate shall be inclusive for compliance with the Specification together with all necessary testing and trials for concrete containing superplasticisers.

5.01.3 DEFINITIONS

A. Crushing Strength

The crushing strength of a test cylinder prepared in accordance with AASHTO T23 and AASHTO T126 or standard cubes prepared with accordance to BS specifications.

B. Average Strength

The mean of the crushing strengths of specimens taken from a sample of concrete.

C. Characteristic Strength

The value of the crushing strength below which 5% of the population of all possible strength measurements of the specified concrete are expected to fall.

D. Fresh Concrete

Concrete during the first two hours after the addition of water to the mix.

E. Batch

The quantity of concrete mixed in one cycle of operations of a batch mixer, the quantity of concrete conveyed ready-mixed in a vehicle or the quantity discharged during one minute from a continuous mixer.

F. Sample

A quantity of concrete taken from a batch whose properties are to be determined.

G. Regular Sampling

The sampling of concrete nominally of the same mix received regularly from the same source.

H. Specimen

Cylinder or cube taken from a sample for testing.

5.01.4 CONCRETE STRENGTH REQUIREMENTS

A. Design Mixes

A.1 Mixes for the classes of concrete (shown in Table 5.1.4) shall be designed by the Contractor. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the particular location required. Unless otherwise approved by the Engineer, the mix designs shall use continuously graded aggregates. All mix designs shall be submitted to the Engineer for approval.

A.2 The Cement content in any mix shall not exceed 450 kg/m^3.

A.3 The 7-day compressive strength of any mix shall not be less than 75% of the specified 28 day strength. If the 7-day result is below the 75% requirement, the Contractor shall postpone works related to the suspected concrete until the 28 days results are available, unless otherwise agreed to by the Engineer, at the Contractor's risk.

A.4 The ultimate compressive strength of concrete shall be determined on test specimens obtained as follows:

Either: Test cylinders prepared and tested in accordance with AASHTO T23 and AASHTO T126. Six inch by twelve inch cylinders shall be used for all compression tests.

Or: Cubes prepared and tested in accordance with BS 1881.

TABLE 5.1.4: CONCRETE CLASS AND DESIGN MIXES

Class of Concrete	Cylinder Works Strength at 28 days: Kg/cm^2	Equivalent Works Cube Strength @ 28 days: Kg/cm^2	Maximum Size of Aggregate: mm	Minimum Cement Content Kg/m^3
110/25 (Blinding)	110	140	25	220
140/25	140	180	25	250
170/60	170	210	60	275
210/50	210	260	50	300
210/25	210	260	25	325
210/20 (B20)	210	260	20	325
250/20 (B25)	250	310	20	350
250/30	250	310	30	350
310/20	310	385	20	375
360/20	360	450	20	425
400/20	400	500	20	425
500/20	500	625	20	425
600/20	600	750	20	425

B. Nominal Concrete Mix

B.1 General

Concrete for use as backfilling for structural excavation shall be either no-fines concrete or cyclopean concrete as directed by the Engineer. The cement: aggregate ratio of such mixes shall be not greater than 1:15 and the minimum cylinder strength at 28 days shall be not less than 50 Kg/cm^2 or minimum 28-day cube strength shall no be less than 60 Kg/cm^2.

B.2 No-Fines Concrete

No-fines concrete shall comply with the grading in Table 5.1.5 and shall be mixed and laid in general conformity with this Section 5.01.

B.3 Cyclopean Concrete

Plums used in cyclopean concrete shall consist of non-reactive broken stone spalls or boulders ranging in size from 200mm to 300mm. They shall be free from sharp or angular edges and shall not form more than 30% of the total volume of concrete. They shall be evenly graded and shall be soaked in water prior to incorporation in the mix. Plums shall be evenly distributed in the concrete mix with a minimum cover of 100mm. The compressive strength the rock plums shall be at least 100 Kg / cm^2 to ASTM D2938. The concrete used in cyclopean concrete shall be Class B20

TABLE 5.1.5: GRADING FOR NO-FINES CONCRETE

Sieve Size	% by Dry Weight Passing
90 mm	100
40 mm	85-100
20 mm	0 - 20
10 mm	0 - 5

C. Compliance with Strength Requirements

C.1 General. Cylinders or cubes from concrete as mixed for the Work will be tested in accordance with AASHTO T22 or BS 1881, as appropriate, after both seven and twenty eight days. Test specimens shall be made and cured in accordance with AASHTO T23 or BS 1881. These specimens will be the basis for acceptance of the concrete in the structure.

C.2 Preliminary Tests

C.2.1 Prior to the commencement of any concreting work and subsequently, whenever a change in the mix is intended, preliminary tests shall be carried out. From each of three samples of materials, a trial mix shall be made. For each class of concrete, the trial mixes shall represent at least two different water- cement ratios. From each trial mix, six cylinders (or cubes) shall be made, three for testing at 7 days, and three for testing at 28 days. The average strength of the cylinders (or cubes) tested for each sample shall be taken as the preliminary cylinder (or cube) strength of the mix.

C.2.2 The Engineer will require the preliminary test to be repeated if the difference in strength between the greatest and the least strength is more than 20 per cent of the average.

C.2.3 The water /cement ratio and slump adopted in the preliminary tests for each class of concrete shall be used in the works concrete. It shall be such that, if selected for use at the Site, the concrete can be worked readily into the corners and angles of the forms and around the reinforcement without permitting the materials to segregate or free water to collect on the surface.

C.2.4 Preliminary tests shall have these minimum ultimate strengths given in Table 5.1.6.

C.3 Works Tests

C.3.1 During the first four days of the commencement of concreting with any particular mix, two sets of six works cylinders (or cubes) in each set shall be made each day. Three cylinders (or cubes) from each set shall be tested at 7 days, and 3 at 28 days. The above works tests shall be carried out for each class of concrete. Subsequently, the frequency of making sets of test cylinders (or cubes) and the number in each shall be as directed by the Engineer.

TABLE 5.1.6: PRELIMINARY TESTS FOR STRENGTH

Class of Concrete	Cylinder Strength (Kg/cm^2)	Equivalent Cube Strength (Kg/cm^2)
110/25	170	210
140/25	210	260
170/60	240	300
210/50	290	360
210/25	290	360
210/20	290	360
250/20	325	400
250/30	325	400
270/20	350	430
310/20	395	490
360/20	440	550
400/20	480	600
450/20	520	650

C.3.2 The cylinders (or cubes) shall be cured in the same conditions and environment as the members they represent. The cylinder (or cube) strength shall be accepted as complying with the specified requirement for work cylinder (or cube) strength if none of the compressive strengths of the cylinders (or cubes) falls below the minimum strengths given in Table 5.1.4 or if the average strength is not less than the specified minimum works cylinder (or cube) strength and the difference between the greatest and least cylinder (or cube) strength is not more than 20 per cent of the average.

C.3.3 For the concrete batch to be accepted, not more than 5 per cent of works cylinder (or cube) strengths shall fall below the specified strength. For this requirement to be achieved, the mean strengths of works cylinders (or cubes) less 1.64 times the standard deviation should not be less than the required strength. This calculation shall be made for both 7 and 28 day cylinder (or cube) tests as soon as 24 cylinders (or cubes) have been tested at each age. Thereafter, it shall be repeated as further test results become available at a frequency determined by the Engineer. The number of cylinders (or cubes) considered in each calculation shall be the total number of cylinders (or cubes) of the mix in question tested from the commencement of the Works.

C.3.4 Cores shall be taken in accordance with ACI 318 and tested in accordance with AASHTO T24. Load testing shall be carried out in accordance with ACI 318, chapter 20. The Contractor shall hire an authorized independent laboratory to carry out such tests at his own expense.

C.4 The Engineer shall instruct the preparation of additional test cylinders or cubes if necessary to ascertain the effectiveness of the methods by which the structure is being cured and also to determine when the structure may be placed in service. These cylinders or cubes shall be cured in the field in the same manner as the concrete placed in the structure, and the Contractor shall protect the cylinders or cubes from all damage.

C.5 The Contractor shall take every precaution to prevent damage to the test cylinders or cubes during handling, transporting and storing. He shall be held solely responsible for any test failure caused by improper handing, transportation or any other cause which may be detrimental to the test cylinder or cube.

C.6 In order that the test cylinders or cubes are transported from the field to the laboratory undamaged, the Contractor shall provide a minimum of two approved boxes (one for the Contractor's use and the other for the Engineer's use). Boxes shall be of such size to receive a minimum of six test cylinders or cubes and sufficient space for sawdust packing around all surfaces of the cylinders or cubes. Boxes shall be approved by the Engineer. The Contractor shall, when directed by the Engineer, provide as many additional boxes as may be required by the remoteness and/or magnitude of the concrete work.

C.7 When test cylinders or cubes fail to meet the minimum strength requirements, the Engineer shall instruct core samples to be taken to determine the acceptability of structural elements. The Contractor shall, at his own expense, furnish all equipment required for such core sampling.

5.01.5 COMPOSITION OF CONCRETE

A. Mix Proportions

A.1 The Contractor shall consult with the Engineer on mix proportions at least forty-five (45) days prior to the commencement of concrete work. The actual mix proportions of cement, aggregates, and water shall be determined by the Contractor.

A.2 The Contractor shall, in the presence of the Engineer, prepare trial-mixes for each class of concrete required for the project, made with the approved materials to be used in the Works. The proportions of the trial-mixes shall be such as to produce a dense mixture containing the specified minimum cement content and meeting the workability and the preliminary test strength requirements specified for the designated class of concrete.

A.3 If the materials supplied by the Contractor are of such a nature or are so graded that proportions based on minimum cement content cannot be used without exceeding the maximum allowable water content, the use of admixtures to maintain the water content within the specified limit shall be permitted, subject to the approval of the Engineer. At all times the concrete mix shall satisfy the durability requirements by satisfying the minimum and maximum specified cement and water contents.

A.4 The Engineer shall review the Contractor's trial- mixes against the seven and twenty eight day test cylinder or cube strength results and determine which of the trial-mixes shall be used. If none of the trial-mixes for a particular class of concrete meets the specification, the Engineer shall direct the Contractor to prepare additional trial-mixes. No class of concrete shall be prepared or placed until its job-mix proportions have been approved by the Engineer.

A.5 The approval of the job-mix proportions by the Engineer or his assistance to the Contractor in establishing those proportions, does not relieve the Contractor of the responsibility of producing concrete which meets the specified requirements.

A.6 All costs connected with the preparation of trial-mixes and the design of the job-mixes shall be borne by the Contractor.

B. Design Limits

The following parameters shall be designated by the Engineer within the limits of the specifications:

- The minimum cement content in sacks per cubic metre of concrete.
- The maximum allowable water content in litres per sack of cement, or equivalent units, including surface moisture, but excluding water absorbed by the aggregates.
- The ratio of coarse and fine aggregates.
- Slump or slumps designated at the point of delivery.

C. Changes to Mix Design

C.1 Changes in mix proportions requested by the Contractor to previously approved mix designs shall only be made following approval by the Engineer.

C.2 If, in the opinion of the Engineer, cement is being lost due to windy conditions, the Contractor shall add additional amounts of cement as directed by the Engineer. No additional payment shall be made for the additional cement.

C.3 The Engineer shall instruct the Contractor to change the proportions of any particular mix if conditions warrant such changes to produce satisfactory results. Any such change shall be made within the limits of the specifications at no additional cost to the Contract.

C.4 When, in the opinion of the Engineer, additional protection against concrete deterioration due to a salty environment is necessary, he shall instruct the Contractor to increase the cement content of a particular mix by ten per cent over and above that cement content used in the approved trial-mix design for a non-salty environment, irrespective of the use of water barriers. The water content shall be adjusted accordingly to obtain a dense workable mix. All bridge footings and column lengths to the first construction joint above the ground surface for the entire project are subject to this increased cement content. No additional payment shall be made for the increase in cement content.

C.5 Failure of the mix to meet specifications determined by the Engineer under items A and B in this sub-section will be grounds for the Engineer to reject the concrete.

C.6 Mortar for laying stone for grouted stone riprap, grouted stone wash checks or grouted stone ditch lining shall be composed of one part of Ordinary Portland Cement and three parts of fine aggregate by volume with water added to make a workable mix. The amount of water added to the mix shall be approved by the Engineer.

C.7 Aggregates for masonry mortar shall conform to AASHTO M45.

C.8 Portland cement shall conform to AASHTO M85, Type I, II or III.

5.01.6 REQUIREMENTS FOR COMBINING MATERIALS

A. Measurement of Materials in Mix

A.1 **Cement** shall be measured in bulk or as packed by the manufacturer (in 50 kilogram sacks). Measurement shall be accurate to within (+/-) 3.0 %.

A.2 **Water:** The mixing water shall be measured by weight or by volume. In either case the measurement shall be accurate to within (+/-) 2.0 %.

A.3 **Aggregates:** The aggregates shall be measured by weight. The measurement shall be accurate to within (+/-) 2.0% for fine and coarse aggregates.

A.4 **Additives:** Additives shall be measured by volume if in liquid form and by weights if solid. The measurement shall be accurate to within (+/-) 3.0 %.

B. Assembly and Handling of Materials

B.1 **Assembly:** Aggregates shall be delivered and stored in such quantities that sufficient material approved by the Engineer is available to complete any continuous pour necessary for structures. The batching site shall be of adequate size to permit the stockpiling of sufficient unsegregated material of uniform moisture content to ensure continuous operation. The Contractor shall take measures to ensure that no foreign matter or materials capable of changing the desired proportions are included n

the mix. If two or more sizes or types of coarse or fine aggregates are used on the same Project, only one size or type of each aggregate may be used on a continuous pour.

B.2 Stockpiling of Aggregates: All aggregates shall be stockpiled before use in order to prevent segregation of material, to ensure a uniform moisture content and to provide uniform conditions for proportioning plant control. The use of equipment or methods of handling aggregates which results in the degradation or segregation of the aggregates is strictly prohibited. Bulldozers with metal tracks shall not be used on coarse aggregate stockpiles and all equipment used for handling aggregates shall be approved by the Engineer. Methods of stockpiling aggregates shall be approved by the Engineer. Segregation shall be prevented by making no layer higher than 1.5 metres and, if two or more layers are required, each successive layer shall not be allowed to "cone" down over the next lower layer. Aggregates shall not be stockpiled against the supports of proportioning hoppers or weighing devices.

B.3 Segregation: Segregated aggregates shall not be used until they have been thoroughly remixed and the resultant pile is of uniform gradation at any point from which a representative sample is taken. The Contractor shall remix aggregate piles when so ordered by the Engineer.

B.4 Transporting of Aggregates: If aggregates are to be transported from a central proportioning plant to the mixer in batch-boxes or dump trucks, such equipment shall be of sufficient capacity to carry the full volume of materials for each batch of concrete. Partitions separating batches shall be approved by the Engineer and shall be adequate and effective to prevent spilling from one compartment to another while in transit or being deposited.

B.5 Storage of Cement: Cement may be stored in securely locked dry places either in bulk (unpacked) or in bags.

a) All cement bags shall be marked with the date of manufacture and with the date of storage so that they can be taken out for use in the same order as they were brought in to storage.

b) Cement bags shall be placed on wooden shelves at least 100 mm above ground and 150 mm clear of walls.

c) Unpacked cement shall not be used six months after manufacture and bagged cement three months after manufacture unless it has been retested in accordance with 5.01.02 A13.

d) No cement shall be used which has been affected by humidity regardless of the date of manufacture.

e) Cement shall be transported to the mixer in the original sacks. Each batch shall contain the full amount of cement for the batch. Batches where cement is placed in contact with the aggregates may be rejected unless mixed within 1.5 hours.

C. Mixing

Concrete shall be mixed in the quantities required for immediate use. Concrete shall not be used which has developed initial set. Retempering concrete by adding water or by other means shall not be permitted. Concrete that is not within the specified slump limits at the time of placement shall not be used and shall be disposed of as directed by the Engineer.

C.1 If washed sand is used while still wet the mixing time starts with the addition of cement to the aggregate, even if the water required for the mixing has not been added.

C.2 The concrete shall be mixed at the site of the Works, in a central-mix plant, or in truck mixers. The mixer shall be of a type and capacity approved by the Engineer. Ready-mixed concrete shall be mixed and delivered in accordance with the requirements of Sub-Section 5.01.7 "Ready-Mixed Concrete and Central-Mixed Concrete".

C.3 The coarse aggregate shall first be loaded into the mixer followed by the fine aggregate. Some mix water shall be added to the mix before the cement is loaded into the mixer. Water shall be continuously added throughout mixing. Additives, if required and approved by the Engineer, shall be added according to the manufacturer's instructions. Retarders shall be added within one minute or 25% of the total mixing time whichever is the smaller.

C.4 The manufacturer's instructions shall be followed in respect of overloading the mixer and the selection of the rate of revolution of the mixers.

C.5 To avoid segregation in the fresh concrete, the free drop height on emptying the mixer shall be not greater than 1.5 metres.

C.6 After mixing, the concrete shall be homogeneous and comply with the provisions of these specifications. The Engineer shall, if the mix fails to produce concrete of the required strength, vary the mix time.

D. Central Mixing

Plants for concrete shall comply with the following requirements, in addition to those set forth above:

D.1 **Cement:** The provisions for storing cement shall be approved by the Engineer. The Contractor shall clean all conveyors, bins and hoppers of previous cement batches before starting to manufacture concrete for the Works.

D.2 **Aggregate:** Coarse and fine aggregate to be used in concrete shall be kept in stockpiles and bins apart from aggregate used in other work. Aggregate shall be provided from a source approved by the Engineer. The Contractor shall clean all conveyors, bins and hoppers of previous aggregate batches before starting to manufacture concrete for the Works.

D.3 **Consistency:** The Contractor shall be responsible for producing concrete that is homogeneous and complies with the provisions of these specifications.

D.4 Hauling: Mixed concrete from the central-mixing plant shall be transported in truck mixers, truck agitators or non-agitating trucks having special bodies or other approved containers.

D.5 Time of Haul: The time elapsing from the time water is added to the mix until the concrete is deposited in place shall be not greater than the following:

For concrete produced on site and transported by means other than transit mixers or agitated trucks.

- Thirty minutes when the air temperature is 25°C or higher.
- Forty minutes when the air temperature is 18°C or below.
- Interpolated time when the air temperature is between 18°C and 25°C.

For concrete transported by transit mixer or agitators, the time taken for 300 revolutions of the transit mixer or agitator or 20 minutes, whichever is the lesser.

The maximum haul time may be reduced at the Engineer's discretion if the slump changes or there are signs of the concrete beginning to dry.

D.6 Delivery: When supplying concrete from a central plant, the Contractor shall have sufficient plant capacity and transporting equipment to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be regulated to provide for proper handling, placing and finishing of the concrete and the method of delivery and handling the concrete shall be organised to facilitate placing with a minimum of rehandling and avoidance of damage to the structure or the concrete. Methods of delivery and handling for each site shall be approved by the Engineer. The Engineer shall delay or suspend the mixing and placing of concrete at any site, for which he considers the Contractor's delivery equipment inadequate, until such time as the Contractor provides additional approved delivery equipment.

5.01.7 READY-MIXED AND CENTRALLY- MIXED CONCRETE

A. General

A.1 Ready-Mixed Concrete and Centrally-Mixed Concrete shall consist of a mixture of cement, water and aggregate, without air entrainment or water-reducing admixture. Air-entrainment, water-reduction or other type of admixture shall only be used at the Engineer's discretion. The terms ready-mixed or central-mixed concrete shall include transit-mixed concrete and will be referred to hereinafter as ready-mixed concrete.

A.2 Ready-mixed concrete shall only be used in construction of the Works with the Engineer’s approval.

A.3 Approval of any ready mixed concrete plant will be granted only when an inspection of the plant indicates that the equipment, the method of storing and handling

the materials, the production procedures, the transportation and rate of delivery of concrete from the plant to the point of use, all meet the requirements set forth herein.

A.4 Ready-mixed concrete shall be mixed and delivered to the point of use by means of one of the following combinations of operations:

a) Mixed completely in a stationary central mixing plant and the mixed concrete transported to the point of use in a truck mixer or tank agitator operating at agitator speed, or when approved by the Engineer, in non-agitating equipment (centrally-mixed concrete).

b) Mixed completely in a truck mixer at the batching plant or while in transit (transit-mixed concrete).

c) Mixed completely in a truck mixer at the point of use following the addition of mixing water (truck-mixed concrete).

A.5 Permission to use ready-mixed concrete from any previously approved plant shall be rescinded upon failure to comply with the requirements of the Specification.

B. Materials

All materials used in the manufacture of ready-mixed concrete shall conform to the requirements of Sub-Section 5.01.2: Materials.

C. Equipment

Equipment shall be efficient, well maintained and of the type and number as outlined in the Contractor's Programme of Work. Transit mixers and agitator trucks shall comply with the standards specified in ASTM C94. Non-agitating equipment used for transporting concrete shall be watertight and equipped with gates permitting controlled discharge of concrete and fitted with covers for protection against the weather.

D. Supply

D.1 Where transit mixers are used, the constituent materials shall be mixed dry in the mixer and water added directly before the pour and mixed at the speed and number of turns in accordance with the manufacturer’s recommendations.

D.2 Where concrete is mixed at a central plant, on or off site, the concrete shall be supplied to the pouring area by agitator trucks or transit mixers which rotate at the speed specified by the manufacturers. Non-agitating trucks shall only be permitted if the central plant is on site.

D.3 The time of haul shall not exceed the maximum stated in sub-item D.5 of subsection 5.01.6 of the Specification.

E. Uniformity Tests

Four samples of fresh concrete shall be taken, two after 15% of discharge from the truck mixer or agitator truck and two after 85% discharge and within 20 minutes. Slump and compaction factor tests shall be carried out including any other tests specified or required by the Engineer.

F. Samples

F.1 Samples for strength test shall be taken as specified in Clause C of subsection 5.01.4 of the Specification.

F.2 At least six specimens shall be prepared per sample. Three of these shall be tested at 7 days and three at 28 days.

G. Control of Delivery

G.1 Drivers of delivery trucks shall be provided with trip tickets, which shall be signed by a responsible member of the central plant staff, for submission to the Engineer. The ticket shall contain the following information.

- Name and address of the Central Plant.
- Serial number of the ticket and date.
- Truck number.
- Class and/or strength of concrete.
- Cement content of the mix.
- Loading time.
- Slump
- Any other relevant information.

G.2 The Engineer shall send representatives to the central plant at any time to:

- Check the batching and mixing.
- Verify loading time.
- Take a copy of the trip ticket.

G.3 The Contractor and/or concrete supplier shall afford the Engineer and/or his representative, without charge, all facilities necessary to take samples, conduct tests and inspect the central plant to determine whether the concrete is being furnished in accordance with the Specification.

G.4 Concrete delivered in outdoor temperatures lower than 5 ^{o}C, or if the temperature is expected to drop below 5 ^{o}C during the curing period, shall arrive at the Works having a temperature of not less than 10 ^{o}C nor greater than 32 ^{o}C.

G.5 In supplying ready-mixed concrete, the plant shall have sufficient batching and transporting capacity to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be sufficient for the proper handling, placing and finishing of concrete. If the rate of delivery is not sufficient for a continuous concrete operation, the Engineer shall suspend all or parts of further concrete work until such time as the Contractor provides adequate additional delivery equipment which, in the opinion of the Engineer, provides a continuous concrete operation.

5.01.8 MEASUREMENT

A. Scope

Concrete works to be measured for payment under Section 5.01 include mass, reinforced and prestressed concrete of both in-situ and precast construction of a general nature but do not include specific components of highway structures, such as concrete piles, concrete parapets and safety barriers, precast concrete kerbs and tiles etc., which are separately described in other sections of the Specification.

B. Measurement

B.1 Concrete shall be measured by the cubic metre in place and accepted by the Engineer, based on the dimensions shown on the Drawings or as otherwise directed by the Engineer.

B.2 Different classes of concrete shall be measured separately.

B.3 Concrete formed by different types of formwork and/or falsework shall be measured separately.

B.4 Concrete of the same class requiring the same formwork but different class of surface finish shall be measured separately.

B.5 Voids, openings or gaps whose size is 0.05 cubic metres or more shall be measured and deducted from the volume of concrete in which they occur.

B.6 All service ducts, irrespective of diameter, shall be measured and deducted from the volume of concrete in which they are located.

B.7 The following deductions in the measurement of the volume of concrete shall not be made:

- Reinforcing bars
- Prestressing ducts, anchors, cones, couplers and grouting tubes
- Embedded metals (bolts, nuts, anchorages, hooks etc)
- Rock plums

- Holes introduced by the Contractor for the convenience of transportation, erection or construction shall not be measured for deduction irrespective of the size of the holes and whether or not the holes are made good.

B.8 Additional concrete placed by the Contractor for the purpose of facilitating his work shall not be measured for payment.

C. Item Coverage

The Contract price paid per cubic metre for concrete shall include full rates for furnishing all labour, materials, tools, equipment and incidentals including, but not limited to, the following: -

- Cement, aggregates, water and additives, admixtures and air entraining agents including their testing, storage, handling and transportation.
- Washing of aggregates, if required.
- Ice, if required, added in the mix water.
- Plant, machinery and equipment required for the production of concrete.
- Design of mixes, taking samples and testing specimens.
- Transportation and delivery of concrete to work areas.
- Placing, vibrating and finishing of concrete.
- All formwork irrespective of the material used and the quality of surface finish specified.
- All falsework supporting and stabilising formwork.
- Curing of concrete.
- Tooling, if required, to achieve the specified surface finish.
- Corrective measures and the means of carrying them out required in the event of the concrete being not in accordance with the Drawings and/or specification.
- Handling, transportation and erection of precast concrete members.
- Grout and/or epoxy used in precast construction including material and equipment for temporary prestress, if required.
- Material, plant and equipment associated with particular methods of construction.
- Joint fillers, joint sealants, weep holes, water stops, dowel bars as shown on the drawings including material, plant handling, transportation testing, storage, workmanship and associated accessories.

SECTION 5.02: CONCRETE HANDLING, PLACING AND CURING

5.02.1 SCOPE

The work covered in this Section consists of the placing, compacting and curing of concrete for mass concrete, reinforced concrete and prestressed concrete structures.

5.02.2 MATERIALS

All concrete materials shall comply with Specification section 5.01: Concrete Mixes and Testing.

5.02.3 PLACING

A. General

A.1 Before preparing and placing any concrete, the Contractor shall submit a work plan to the Engineer for approval, specifying the characteristics of the concrete to be employed, the time at which placing is to start the methodology and the duration. The Engineer's approval at least 24 hours in advance of each placing is required.

A.2 The method and sequence of pour, the equipment to be used, the method of compaction and curing procedures shall be approved by the Engineer, prior to any concrete pour.

A.3 In order to allow satisfactory vibration, the concrete shall be placed in horizontal layers, no thicker than fifty centimetres.

A.4 If the concrete is placed in successive phases, there shall be no separation, discontinuity or difference in appearance between the two successive placings. Before each successive placing, the surface of the in-place concrete shall be carefully roughened, cleaned, washed free of loose particles and dampened.

A.5 Concrete shall be placed so that it shall be undisturbed once trowelled. Slabs shall be poured by starting placement of concrete at the location furthest away from the access point to minimise disturbance by workers or equipment.

A.6 Concrete placed in upright reinforced concrete structures shall either be completed or interrupted for a period of twenty-four hours to avoid the risk of the placed concrete debonding from the reinforcing bars during setting and the initial phase of hardening.

A.7 The temperature of the concrete being placed shall be of the same magnitude as that of the reinforcing bars to avoid poor adhesion. The reinforcing bars shall be protected from the sun or cooled by water jets prior to the placing of the concrete or the pouring shall start during the cooler hours of the day and be suspended when the temperature rises above 33 ^{o}C, unless otherwise agreed with the Engineer.

A.8 The free-drop height of concrete shall be not greater than 1.5m and the method of placing shall suit the conditions and prevent segregation.

A.9 Placing of concrete shall be continuous between predetermined points such as construction joints, contraction joints and expansion joints.

A.10 Concrete shall be placed to avoid segregation of the materials and displacement of the reinforcement. Concrete shall not be deposited in large quantities at any point and then run or worked along the forms, causing potential segregation of materials.

A.11 The concrete shall be deposited between the forms in horizontal layers and the work shall be carried out continuously between predetermined planes agreed upon by the Contractor and the Engineer.

A.12 The slopes of chutes, where used, shall be not greater than 1 vertical to 2 horizontal or smaller than 1 vertical to 3 horizontal. The slope of the chute shall be constant along its length. The capacity of the chute shall be adequate to deliver the required volume of concrete at the required rate.

A.13 Aluminium pipes shall not be used for delivering concrete. The internal diameter of delivery pipes, if used, shall be not less than 8 times the maximum aggregate size. At the point of delivery, pipes shall be vertical.

A.14 Where buckets and hoppers are used for delivery of concrete, the discharge opening shall be not less than 5 times the maximum aggregate size. The sides of hoppers shall be sloped at not less than 60 degrees to the horizontal.

A.15 When buggies are used to transport fresh concrete, they shall be run on level tracks, which are securely fixed. The buggies shall be run smoothly without sudden jerks and the distance travelled shall be not greater than 60 metres.

A.16 All chutes, buckets, hoppers, buggies and pipes shall be kept clean and free from coatings of hardened concrete by thorough flushing with water after each pour. The water used for flushing shall be discharged clear of the concrete already in place.

A.17 The external surface of all concrete shall be thoroughly worked during the placing using appropriate tools. The method of working shall force all coarse aggregate from the surface and bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets and honeycombing.

A.18 Concrete shall be deposited in water only with the permission of the Engineer and under his supervision. The minimum cement content of the class of concrete being deposited in water shall be increased 10 per cent without further compensation and the slump shall be approximately 15 centimetres.

A.19 When depositing in water, the concrete shall be carefully placed in the space in which it is to remain in a compact mass, using a tremie, bottom-dumping bucket or other method approved by the Engineer that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. No concrete shall be placed in running water. Forms that are not reasonably watertight shall not be used for holding concrete deposited under water.

A.20 When casing is used in drilled shafts, the casing shall be smooth and properly oiled in accordance with the manufacturer's recommendations and shall extend sufficiently above the grade of the finish shaft to provide excess concrete to compensate for the anticipated slump due to the casing removal. The concrete placed in the casing shall have such a slump and be of such workability that vibration of the concrete is not required.

A.21 No concrete work shall be stopped or discontinued within 45 centimetres of the top of any finished surface unless such work is to be finished with a coping having a thickness of less than 45 centimetres. In this case the joint shall be made at the underside of the coping.

A.22 Concrete in slab spans shall be placed in one continuous operation for each span, unless otherwise shown on the Drawings or directed by the Engineer.

A.23 Concrete in in-situ beam and slab construction shall be placed in one continuous operation, unless otherwise shown on the Drawings or approved by the Engineer. If concrete is to be placed in two separate operations, each placement shall be continuous; first, to the top of the girder stems, and second, to completion. Where a construction joint is permitted between the girder stem and the roadway slab, shop drawings including complete details of key or other methods of bonding shall be prepared by the Contractor and submitted to the Engineer for approval. When such a joint is permitted, deck concrete shall not be placed until the concrete in the girder stem has hardened sufficiently so as not to be damaged by the concreting operations of the deck pour.

A.24 Concrete in arch rings shall be placed so that the cantering is loaded uniformly. Arch rings shall be divided into sections such that each section can be cast for the full cross-section in one continuous operation. The arrangement of the section and the sequence of placing shall be as approved by the Engineer and shall avoid the creation of initial stress in the reinforcement. The section shall be bonded together by suitable keys or dowels. When permitted by the Engineer, arch rings shall be cast in a single continuous operation.

A.25 The method used for transporting concrete batches, materials or equipment over previously placed floor slabs or floor units or over units of structures of continuous design types shall be subject to approval by the Engineer. Trucks, heavy equipment and heavy concentrations of materials are prohibited on floor slabs until the concrete has attained its design strength.

B. Pumping

B.1 The use of pumps shall be permitted only after they have been checked and approved by the Engineer. Only low pressure piston type pumps, working with a water/cement ratio of not more than sixty five hundredths (0.65), shall be permitted. The use of superplastizisers to facilitate pumping for low water/cement ratios shall be permitted, subject to Engineer's review and approval.

B.2 The use of high pressure pumps for pumping concrete is not permitted.

B.3 The mix design shall be checked and approved by the Engineer for suitability for pumping and the concrete shall be tested regularly during pumping for its uniformity and fitness for purpose. If changes to slump, water-cement ratio, consistency or any other characteristics occur, corrective measures shall immediately be taken to ensure that concrete delivered by the pump complies with the requirements of the Specification. Samples shall be taken at the discharge from the mixer/agitator trucks, from the pumps and at the discharge from the pumps.

B.4 The internal diameter of pump delivery pipes shall be not less than three times the maximum aggregate size. The pipes shall not rest on any part of the formwork and shall be supported independently and securely and be readily accessible so that sections can easily be detached to remove any blockage.

B.5 Before approving the use of a pump, the Engineer shall verify that the Contractor has sufficiently resources in the concrete placing team and the necessary equipment for placing and vibrating the concrete.

B.6 The placing of pumps within the forms while concrete is being placed shall not be permitted. When flood prevention is necessary, a seal of concrete shall be placed through a closed chute or tremie and allowed to set to form a barrier.

5.02.4 COMPACTION

A. General

A.1 The vibration of the concrete shall be considered completed when a thin layer of cement grout appears on the surface and when no more air bubbles, indicating the presence of voids within the concrete, appear on the surface. Vibration shall be limited to prevent segregation.

A.2 Vibration shall be carried out by one of the following methods:

- Internal
- External
- Mixed.

A.3 Vibration shall be carried out in accordance with the guidelines as given in Standard Practice for Consolidation of Concrete (ACI 309) of Part 2 Concrete Practices and Inspection, Pavements, of ACI Manual of Concrete Practice 1988 issued by American Concrete Institute (ACI), unless otherwise directed by the Engineer.

A.4 Internal Vibration shall be executed in all sections which are sufficiently large to permit the insertion and manipulation of immersion vibrators, previously approved by the Engineer and in accordance with the following recommended practices:

- The concrete shall be placed in horizontal layers no thicker than fifty centimetres.
- The vibrator shall be inserted vertically into the concrete to its full length to reach the bottom of the freshly placed layer.
- The distance between two successive insertions shall not exceed five times the diameter of the vibrator itself.
- The vibrator shall not rest on or against either the formwork or the main reinforcing bars.

A.5 External Form Vibrators shall be used for external vibration when it is impossible to use internal vibrators (heavily reinforced thin walls, pipes or other precast, small cross-section element, etc). The water/cement ratio shall be low (0.30 - 0.40) in order to avoid segregation of the concrete, to provide rapid hardening and for the early removal of formwork.

A.6 Mixed Vibration shall be used in the construction of reinforced or prestressed concrete beams. External wall vibrators shall also be used, mounted on the outside of the formwork after this has been suitably reinforced with ribs of U-bars. The mounting of the wall vibrators shall be welded to this reinforcement. Mountings shall be symmetrically positioned on each side of the beam to produce a rotary movement within the concrete during vibration from the bottom towards the top and from the part placed first towards the part placed last.

A.7 Only vibrators in the zone of the formwork with newly placed concrete shall be used. As the casting of the beam advances, the vibrators shall be dismounted and remounted as necessary.

A.8 Elastic supports shall be provided both under the bottom of the beam and in alignment with the braces or tie rods of the formwork walls.

A.9 The network of reinforcing bars and tensioning cables shall not move as a result of the vibration. Special ties (passing through the formwork walls) or spacers shall be used.

A.10 The Contractor shall submit to the Engineer a method statement for approval of his vibration proposals prior to carrying out the work, giving the following details:

- The position of the external wall vibrators.
- The power, frequency and amplitude of the external wall vibrators.
- The number of wall vibrators that will be utilized at the same time.
- The number and type (frequency and size) of the internal vibrators to be used for the consolidation of the concrete.
- The position of the spacers, or the number of ties, to be used to ensure that the reinforcing bar network and the tensioning cables (if any) do not move during vibration.
- The method of placement of concrete and the length of time this operation is expected to take.

A.11 When required, vibration shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

B. Poker Vibrators

B.1 The type and size of poker vibrators shall suit the pour size, density of reinforcement and member dimensions. Unless otherwise authorized by the Engineer, the vibrators shall be selected from Table 5.2.1 below:

TABLE 5.2.1: SELECTION OF POKER DIAMETER FOR SIZE OF POUR

Size of Pour (m^3/h)	Poker Diameter (mm)	Speed (Vibrations/min)
2 - 4	20 - 45	9000
5 - 10	50 - 65	9000
10 - 20	60 - 75	7000
20 - 30	80 - 115	7000
30 - 40	140 - 170	6000

B.2 Poker vibrators shall be inserted into the concrete vertically at regular intervals which shall be no greater than 0.5m. They shall be inserted quickly and withdrawn slowly. The withdrawal rate shall be not more than 75mm/sec. the cycle of insertion and withdrawal shall be between 10 and 30 seconds.

B.3 Poker vibrators shall be kept clear of formwork and concrete previously cast.

B.4 Vibrators shall be manipulated to work the concrete thoroughly around the reinforcement and embedded fixtures and into the corners and angles of forms. Vibrators shall not be used to make concrete flow or run into position in lieu of placing.

B.5 Compaction shall be sufficient to achieve the maximum density without segregation in the fresh concrete.

B.6 Standby pokers of the same type shall be provided at all times. The number of spares shall be not less than half the number of pokers used for compaction of the pour.

B.7 Vibration shall only be carried out by operatives having previous experience in this type of work.

C. Other Vibrators

C.1 Form vibrators, vibrating tables and surface vibrators where required shall first be approved by the Engineer and shall conform to the requirements of ACI-309.

C.2 Where form vibrators are used, the form shall be adequately designed so that the vibration does not cause joints to leak or dimensions and geometry to alter.

C.3 Unless otherwise permitted by the Engineer, the use of form vibrators shall be limited to members whose thickness does not exceed 150 mm.

5.02.5 CURING

A. Materials

A.1 **Hessian or Burlap** shall be clean and free from harmful materials. The unit weight of either hessian or burlap shall be not less than 230g/ m^2.

A.2 **Impermeable membranes:** The following impermeable membranes may, with the Engineer's approval, be used.

- Clear polyethylene film with no holes, tears, scratches or contamination of any type.
- Hessian coated with white polyethylene of density not less than 300g/sq.m. The coating may be on one side only but shall be not less than 0.1mm thick and shall not peel during and after use.

A.3 **Curing Compounds** shall conform to AASHTO M148 (ASTM-C309).

A.4 **Sand** shall be natural sand, free of silt, clay and other contaminants harmful to the concrete.

A.5 **Water** shall satisfy the requirements of Section 5.01 of the Specification.

B. Method of Curing

B.1 General: The method of curing shall be approved by the Engineer. It shall not cause any undesirable blemishes such as surface discoloration and surface roughness. Curing compounds shall not be used on construction joints and surfaces that are to receive waterproofing, paint or membranes.

B.2 Ponding: Curing by ponding may be used for horizontal surfaces such as bases, pile caps and slabs. Large horizontal surface areas shall be separated into ponds not exceeding 5 m^2. The ponds shall first be filled between 12 to 24 hours after the pour, unless otherwise authorised by the Engineer, and shall be replenished from time to time so as to maintain the ponding for the specified curing period. The temperature of the curing water shall be not greater than 10°C.

B.3 Sprinkling: Unless otherwise approved by Engineer, curing by spraying shall commence between 12 and 24 hours after the concrete pour. The concrete shall be maintained in a damp condition at all times during the curing period by periodic light spraying.

B.4 Wet Hessian/Burlap: Members to be cured by wet hessian or wet burlap shall be completely wrapped with the material which shall be kept moist at all times by regular spraying during the curing period. Unless otherwise approved by the Engineer, the overlap under normal conditions shall be not less than one-quarter the width of the hessian or burlap and not less than one-half the width in windy and/or rainy conditions. Before members are wrapped for curing, they shall first be evenly moistened. Unless approved by the Engineer, burlap shall be supplied only in rolls; burlap bags shall not be used. Second-hand hessian and burlap, if approved for use, shall be clean without holes and contamination of any kind.

B.5 Waterproof Sheets: Waterproof sheets used for curing shall, unless directed by the Engineer, be spread immediately after the pour. The sheet shall be clear of the concrete surface but be arranged to prevent air movement over the concrete surface. Waterproof sheets shall not be used when the air temperature is 25°C or higher.

B.6 Curing Compounds: Curing compounds shall be applied in two applications at a rate of not less than 1 litre/ 7.5 m^2 per application or as recommended by the manufacturer.

- The first coat shall be applied immediately after the removal of the forms and acceptance of the concrete finish and after the disappearance of free water on unformed surfaces. If the concrete is dry or becomes dry, it shall be thoroughly wet with water and curing compound applied just as the surface film of water disappears. The second application shall be applied after the first application has set. During curing operations, any unsprayed surfaces shall be kept wet with water. The curing membrane shall not be allowed on areas against which further concrete is to be placed.

- Hand operated spray equipment shall be capable of supplying a constant and uniform pressure to provide a uniform and adequate distribution of the curing membrane at the rates required. The curing compound shall be thoroughly mixed at all times during usage.
- The curing membrane shall be protected against damage for the entire specified curing period. Any coating that has been damaged or otherwise disturbed shall be given an additional coating. Should the curing membrane be continuously subjected to damage, the Engineer shall instruct wet burlap, polyethylene sheeting or other material to be applied at once.
- No traffic of any kind shall be permitted on the curing membrane until the curing period is completed, unless agreed to by the Engineer. Areas damaged by traffic shall be immediately repaired as directed by the Engineer.

B.7 Steam Curing

Low pressure steam curing shall be carried out in accordance with ACI 517 recommendations and high pressure steam curing in accordance with ACI 516.

C. Curing Time

C.1 The minimum curing time shall be the number of days given in Table 5.2.2 below. If the surface temperature of the concrete falls below 10°C the curing time shall be calculated from the equivalent maturity criteria.

TABLE 5.2.2: NORMAL CURING PERIODS

Ambient Weather Conditions	**Minimum Number of Days of Curing Protection where the Surface Temperature of the Concrete Exceeds 10°C for the Whole Curing Period**			**Equivalent Maturity in Degree Celsius Hours – (*The required number of hours of curing of the Concrete multiplied by the Number of °C by which the initial surface temperature of the Concrete exceeds minus 10°C)***		
	OPC or RHPC	**SRPC**	**Other**	**OPC or RHPC**	**SRPC**	**Other**
Hot Weather* or Drying Winds	**4**	**3**	**7**	**2000**	**1500**	**3500**
Other Conditions	**3**	**2**	**4**	**1500**	**1000**	**2000**

KEY. OPC = Ordinary Portland cement.
RHPC = Rapid-hardening Portland cement.
SRPC = Sulphate resisting Portland cement.
* See Clause 5.02.6A

C.2 The minimum curing time given in Table 5.2.2 above shall be compared with the time required for cylinders (or cubes), cured under identical conditions to those which the concrete is subjected, to attain 70% of the characteristic strength. The greater shall be taken as the minimum curing time.

5.02.6 HOT WEATHER CONCRETING

A. Definitions

For the purpose of this sub-section of this Specification, Hot Weather is as defined in ACI 305R-77 (Revised 1982) Chapter 1.

B. General

B.1 The production, delivery, placing, curing, testing and inspection of concrete shall be in accordance with these Specifications and the recommendations of ACI 305R-77 (Revised 1982).

B.2 No concreting shall commence when the air temperature is 32°C and rising. The Contractor shall schedule his operations to place and finish concreting during the hours that the air temperature will be below 32°C. This should preferably be in the latter part of the day after the maximum temperature has been reached.

C. Control of Temperature

C.1 Aggregate stockpile shall be protected from direct sunlight by suitable covering and periodically sprayed with clean water.

C.2 Water shall be stored in tanks away from sunlight and insulated by suitable means to protect against high air temperatures. Water tanks liable to be exposed to sunlight shall be covered with suitable reflective paint such as white gloss.

C.3 Sufficient ice shall be added to the mix water to ensure that the temperature of the fresh concrete shall not exceed 32°C.

C.4 The temperature of the concrete at the time of placing shall not be permitted to exceed 33 °C. Concrete materials shall be stored in a cool shaded position away from the direct rays of the sun. Prior to mixing, aggregates shall be cooled and water shall be cooled by means of a proprietary water chilling plant as necessary. The prices in the Bill of Quantities shall be deemed to cover all such special work.

C.5 Additives as recommended in ACI 305R-77 shall be used to improve workability and/or delay initial setting.

C.6 Retarding admixtures to facilitate placing and finishing of the concrete shall conform to AASHTO M194, Type D and only be used if approved by the Engineer.

D. Mixing and Placing

D.1 The Contractor shall take appropriate precautionary measures when handling and placing of concrete during periods of high temperatures. Concrete shall be covered with damp hessian during transportation. No additional water shall be added at the time of mixing without the approval of the Engineer, to minimise the risk of additional shrinkage of the concrete. Water shall not be added during transportation or placing of the concrete.

D.2 Aggregates and cement shall be thoroughly pre-mixed before adding water.

D.3 Transit mixers, if used, shall be coated with a reflective paint and shall be kept out of direct sunlight while waiting to be discharged.

E. Concrete Protection

E.1 Before the concrete shutters are struck, the formwork and shuttering shall be cooled with a water spray.

E.2 The concrete and the falsework shall be protected against sunlight.

E.3 Hessian, if used for curing, shall be coated with a white polyethylene backing.

E.4 Concrete exposed to strong winds shall be protected with windbreaks. The windbreaks shall be kept moist by regular spraying.

5.02.7 COLD WEATHER CONCRETING

A. Definitions

For the purpose of this sub-section of this Specification, Cold Weather is as defined in ACI 306.1-87, Section 1, Part 1.2.

B. General

B.1 ACI 306.1-90 "Standard Specification for Cold Weather Concreting" applies.

B.2 The production and delivery of concrete, the placing and curing and the protection requirement shall be in accordance with the recommendations of ACI 306R-88 "Cold Weather Concreting".

B.3 No concreting shall commence when the air temperature is 6°C and falling, unless authorised by the Engineer.

C. Mixing and Placing

C.1 Aggregates, water, forms, reinforcement etc. shall be free of snow, frost or ice.

C.2 If aggregates and water are pre-heated, they shall be mixed together prior to introducing cement. The aggregates shall not be pre-heated to a temperature in excess of 100°C, the water shall not be in excess of 60°C and the temperature of the water and aggregate mix, before the introduction of cement, shall not exceed 38°C.

C.3 If heated water is added to unheated aggregates, the temperature of the water and aggregate mix, before the introduction of cement, shall not exceed 38°C.

C.4 The temperature of concrete at the time of discharge shall be between 10°C and 27°C and for three days after the pour not less than 5°C.

D. Protection

D.1 Concrete shall be protected against cold winds by suitable windbreaks.

D.2 Adequate insulation using boards, planks, sheets etc. shall be provided to maintain the required minimum concrete temperature during the curing period.

D.3 Protection measures shall be maintained until the concrete attains a strength of at least 65% of the characteristic strength.

5.02.8 NIGHT CONCRETING

A. Night concreting shall not be carried without prior approval from the Engineer.

B. Details of the lighting system shall be submitted in advance of the proposed concreting for the Engineer's approval. At least one stand-by generator shall be provided at all times during concreting operation.

5.02.9 MEASUREMENT

The provisions of this section of the Specification are not measured directly for payment but shall be considered subsidiary to the different classes of concrete described and measured for payment under the provisions of Specification Section 5.01: Concrete Mixes and Testing

SECTION 5.03: STEEL REINFORCEMENT

5.03.1 SCOPE

The work covered in this Section consists of the supply and fixing of the unstressed steel bars, wires, mesh and mats for the reinforcement of concrete in accordance with the Drawings and Specification.

5.03.2 MATERIALS

A. Reinforcing Bars

A.1 High tensile steel reinforcement bars shall conform to AASHTO M31 (ASTM A615) Grade 60 (with carbon content not exceeding 0.3%) or to BS 4449:2005.

A.2 Mild steel reinforcing bars shall conform to AASHTO M31 (ASTM A615) Grade 40 or BS 4449:2005.

A.3 High tensile, low-alloy steel deformed bar shall conform to ASTM A706.

B. Welded Fabric Reinforcement

B.1 Welded steel wire fabric shall conform to AASHTO M55 (ASTM A185) or BS 4482:2005.

B.2 Cold drawn steel wire shall conform to the requirements of AASHTO M32 or in the case of hard drawn steel wire to BS 4482:2005.

C. Fabricated Mat Reinforcement

Fabricated mat reinforcement shall conform to AASHTO M54 (ASTM A184).

D. Certification and Identification

D.1 Three copies of a Mill Test Report shall be supplied to the Engineer for each lot of billet steel reinforcement supplied for use on the Contract. The Mill Test Report shall give the following information:

- The processes used in the manufacture of the steel from which the bars were rolled.
- Identification of the furnaces and/or each lot of steel from which the bars were rolled.

D.2 The bars in each lot shall be legibly tagged by the manufacturer and/or fabricator. The tag shall show the manufacturer's test and lot number or other designation that will identify the material with the certificate issued for the lot of steel.

D.3 The fabricator shall furnish 3 copies of a certificate which shows the heat number or numbers from which each size of bar in the shipment was fabricated.

E. Inspection and Sampling

The sampling and testing of reinforcement bars shall be made at the source of supply when the quantity to be shipped or other conditions warrant such procedure. Bars not inspected and sampled before shipment shall be inspected and sampled after arrival at the site.

5.03.3 CONSTRUCTION

A. General

A.1 Reinforcing steel shall be protected at all times from damage. All reinforcement shall be free from dirt, mill scale, scaly rust, paint, grease, oil or other foreign substances. There shall be no evidence of pitting or visual flaws in the test specimens or on the sheared ends of the bars.

A.2 Rust shall be removed by wire brushing or by sand blasting. Light rust without visible sign of peeling need not be removed.

B. Storage

B.1 Reinforcement shall be stored clear of the ground on platforms, skids or other supports and be protected against contamination by dirt, grease, oil etc. If directed by the Engineer, the Contractor shall provide cover to the reinforcement.

B.2 Reinforcement of different grades and different diameters shall be stored separately and appropriately marked to facilitate inspection and checking.

C. Cutting and Bending

C.1 Cutting and bending of reinforcement shall be based on bar bending schedules detailed on the Drawings and/or approved by the Engineer.

C.2 Reinforcement shall be cut using specialist cutting machines or cold cut by hand only. Cutting with oxyacetylene torches is not permitted.

C.3 Bars shall be bent to the following bend diameters:

Bar Diameter (d)	Mild Steel	High Yield Steel
Up to 16 mm	4d	4d
16 to 25 mm	4d	6d
25 to 35 mm	6d	8d
35 to 60 mm	10d	10d

C.4 All reinforcement shall be bent within the temperature range of 5°C and 100°C. Bending by heating shall not impair the physical and mechanical characteristics of the bar.

C.5 The straight bar length for a hook of 180° shall be not less than 4 times the bar diameter or 60mm whichever is the larger.

C.6 The straight bar length of a hook of 90° shall be not less than 12 times the bar diameter.

C.7 The straight bar length after a hook in stirrups shall be 6 times the bar diameter or 60mm whichever is the larger.

C.8 Cold worked bars and hot rolled high yield bars shall not be re-bent or straightened once having been bent, unless otherwise shown on the Drawings. Where it is necessary to bend mild steel bars projecting from the concrete, the bend diameter shall comply with the requirements of item C.3 above.

C.9 If bending of a bar causes the bar to crack, the bar shall be rejected, irrespective of any prior approval that may have been given, and removed from the Site.

C.10 Bars shall be cut and bent to the following tolerances:

Bar Length (mm)	**Tolerance (mm)**
Up to 1000	5
1000 - 2000	+5, -10
Above 2000	+5, -25

C.11 No adjustment to bar length after bending shall be permitted.

D. Fixing

D.1 Reinforcement shall be placed and maintained in the position shown on the Drawings. Unless agreed otherwise by the Engineer, all bar intersections shall be securely tied together with the ends of the wire turned into the main body of the concrete. 1.2 mm diameter stainless steel wire shall be used for in-situ members having exposed soffits; 1.6 mm diameter soft annealed iron wire shall be used elsewhere.

D.2 The correct cover to reinforcement on all exposed faces of concrete shall be maintained by using proprietary spacers. Where instructed by the Engineer the adequacy of such spacers shall be demonstrated by site trials.

D.3 Concrete cover blocks shall be of suitable dimensions and designed so that they shall not overturn when the concrete is placed. They shall be made with 10 mm maximum size aggregate and the mix proportion shall be such as to produce at least the same strength as the adjacent concrete. Tying wire shall be cast in the blocks for subsequent attachment to the reinforcement.

D.4 Wherever it is necessary for the Contractor to splice reinforcement at positions other than those shown on the Drawings, the approval of the Engineer shall be obtained. Splices shall be staggered where possible and shall be designed to develop the strength of the bar without exceeding the allowable unit bond stress.

D.5 Proprietary mechanical splicing devices shall be used only with the prior approval of the Engineer. They shall be able to withstand without slippage a force of not less than 1.25 times the characteristic yield stress of the smaller spliced bar multiplied by the cross-sectional area of the smaller bar.

D.6 Mesh reinforcement shall comply with the sizes of sheets and diameter and spacing of bars as shown on the Drawings. The sheets of mesh shall be lapped as shown on the Drawings. The method of placing and securing the mesh in position shall be approved by the Engineer.

D.7 Welding of reinforcement bars, if permitted, shall be carried out in accordance with the latest publications of the American Welding Society publication "Structural Welding Code for Reinforcing Steel", and shall be able to withstand a force of not less than 1.25 times the characteristic yield stress of the smaller of the welded bars multiplied by the cross-sectional area of the smaller bar.

D.8 Cold worked steel bars shall not be welded.

D.9 Galvanizing or epoxy coating shall be applied to the reinforcement in accordance with the Drawings or where otherwise required with the approval of the Engineer.

D.10 Dowel bars shall be coated over half of each bar with a proprietary debonding compound or fitted with plastic sleeving to the approval of the Engineer. Bars shall be fixed securely at the required level at right angles to and centred on the joint. Compressible caps shall be fitted to debonded ends of bars where necessary in the opinion of the Engineer.

5.03.4 MEASUREMENT

A. Measurement of different grades of steel reinforcement shall be based on the theoretical quantity of metric tonnes complete in place as shown on the Drawings or placed as ordered by the Engineer. No allowance will be made for clips, wire or other fastening devices for holding the reinforcement in place. Measurement shall not be made of reinforcement chairs to separate slab steel or similar reinforcement to retain wall steel or similar usage elsewhere. Measurement of splices in reinforcement not shown on the Drawings will not be made, unless such splices were agreed or authorised by the Engineer.

B. Calculated weights for high tensile and mild steel shall be based upon Table 5.3.1.

TABLE 5.3.1: WEIGHTS OF REINFORCING BARS

Diameter mm	Weight kg/m	Diameter mm	Weight kg/m	Diameter mm	Weight kg/m
5	0.154	18	2.000	32	6.310
6	0.222	20	2.470	34	7.130
7	0.302	22	2.980	36	7.990
8	0.395	24	3.550	38	8.900
10	0.617	25	3.850	40	9.870
12	0.888	26	4.170	45	12.500
14	1.210	28	4.830	50	15.400
16	1.580	30	5.550		

C. Separate measurement shall not be made for bars of different diameters but of the same grade.

D. Fabric mesh reinforcement shall be measured separately and based on the theoretical quantity of metric tonnes complete in place as shown on the Drawings or placed as ordered by the Engineer. No separate measurement shall be made for different mesh sizes or different wire diameters.

SECTION 5.04: FORMWORK AND FALSEWORK

5.04.1 SCOPE

The work covered in this section consists of the design, supply and use of formwork and falsework for the construction of concrete highway structures.

5.04.2 DEFINITIONS

A. Formwork

The section of the temporary works used to give the required shape and support to poured concrete. It consists primarily of sheeting material, such as wood, plywood, metal or plastic sheet in direct contact with the concrete; and joists or stringers directly supporting the sheeting.

B. Falsework

Any temporary structure used to support a permanent structure while it is not self-supporting.

C. Scaffold

A temporary structure that provides access to and/or a working platform for labour, materials, plant and/or equipment.

D. Tower

A composite structure, usually tall, used principally to carry vertical loading.

E. Camber

The intentional curvature of the formwork, formed initially to compensate for subsequent deflection under load.

5.04.3 MATERIALS

A. Wood

A.1 Soft wood shall be free of faults such as splitting, warping, bending, knots etc.

A.2 The minimum grade of softwood used for falsework shall be SC3, determined in accordance with B.S 4978:1996.

A.3 Hardwood used as load-bearing wedges and packing shall be limited to those listed in Table 5.4.1.

TABLE 5.4.1: PERMITTED HARDWOODS FOR LOAD-BEARING WEDGES AND PACKING

Standard Name	**Botanical Species**
Ash	Fraxinus excelsior
Beech	Fagus sylvatica
Greenheart	Ocotea rodiaei
Jarrah	Eucalyptus marginata
Karri	Eucalyptus diversicolor
Keruing	Dipterocarpus spp
Oak	Quercus spp

B. Plywood

When plastic coated plywood is used, the phenol resin on melamine shall be not less than 20% of the total coating weight.

C. Steel

Steel forms shall conform to the requirements of Section 5.16 Structural Steelwork and Metal Components.

D. Aluminium

Aluminium forms shall conform to the requirements of ASTM B221.

E. Other Materials

Other material such as fibre-glass reinforced plastic, polystyrene, polyethylene, PVC, rubber, concrete, and brick shall be permitted for use in formwork if indicated on the Drawings or approved by the Engineer.

5.04.4 DESIGN

A. General

A.1 Formwork and falsework shall be designed by the Contractor and submitted to the Engineer with full design calculations, detailed drawings, material specifications and test certificates for approval. Falsework shall be capable of temperature changes without causing damage to the concrete.

A.2 Falsework design shall be in accordance with B.S 5972 "Code of Practice for Falsework".

A.3 If the Contractor intends to use ready made proprietary type of falsework, he shall submit all relevant data, including independent test certificates, which will enable the Engineer to determine whether or not the Contractor's proposed falsework is acceptable.

A.4 Notwithstanding any approval of falsework design by the Engineer, the Contractor shall not be relieved of his responsibility for the adequacy and correctness of the design, manufacture and assembly of the falsework.

B. Forms and Formwork

B.1 Formwork shall be sufficiently rigid so as to prevent any grout loss during concreting and shall not distort due to environmental effects and concreting operations in order that member dimensions, shape, required finish and texture are within the tolerances specified.

B.2 Forms and formwork shall be designed to be readily assembled, stripped and transported without distortion to panels and members of the formwork.

B.3 The method of stripping forms without damaging the concrete or textured surface finish shall be fully considered in the design.

B.4 If form liners are to be used to achieve the specified surface finish, samples of a size as directed by the Engineer shall be submitted for approval.

B.5 Form lining shall not bulge, warp or blister, nor shall it stain the concrete. Form lining shall be used in the largest practicable panels to minimize joints. Small panels of the lining material shall not be permitted. The joints in the lining shall be tight and smoothly cut. Adjacent panels of form lining shall be so placed that the grain of the wood will be in the same direction (all horizontal or all vertical). Thin metal form lining is not permitted. Undressed lumber of uniform thickness may be used as backing for form lining. Wooden ply form, of adequate thickness which is properly supported to meet the above requirements, may be used in lieu of the lined forms specified herein.

B.6 Metal forms, if used, shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease or other foreign matter. Under such circumstances the continued use of the metal forms will depend upon satisfactory performance and their discontinuance may be required at any time by the Engineer. Steel panels or panels with metal frames and wood or combination shall be designed to leave no lipping or ridges in the finished concrete.

B.7 The width and thickness of the lumber, the size and spacing of studs and wales shall be determined with due regard to the nature of the Work and shall be sufficient to ensure rigidity of the forms and to prevent distortion due to the pressure of the concrete.

B.8 Form bolts, rods or ties and removable ties through plastic (PVC) pipes shall be made of steel. They shall be the type which permit the major part of the tie to remain permanently in the structure or removed entirely. They shall be held in place by devices attached to the wales capable of developing the strength of the ties. The Engineer may permit the use of wire ties on irregular sections and incidental construction if the concrete pressures are nominal and the form alignment is maintained by other means. Form ties shall not be permitted through forms for handrails. Pipe spreaders shall not be used unless they can be removed as the concrete is placed. Wood or metal spreaders shall be removed as the concrete is placed. The use of cofferdam braces or struts shall not be permitted except in unusual situations and with the approval of the Engineer.

B.9 Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

B.10 Unless otherwise directed by the Engineer, the exterior side of forms shall be painted with an approved, good quality high gloss white oil base enamel paint prior to placing concrete. Paint shall be applied to metal forms only. When complete coverage is not obtained with one coat, the Engineer shall order additional coats as he deems necessary to obtain complete coverage. Forms shall be repainted when ordered by the Engineer.

B.11 Unless provided otherwise on the Drawings or directed by the Engineer, all exposed edges shall be bevelled by using dressed, mill cut, triangular moulding, having 20 millimetre sides.

B.12 Forms shall be maintained after erection to eliminate warping and shrinkage.

C. Falsework

C.1 Falsework and centring shall be designed to provide the necessary rigidity to support all loads placed upon it without settlement or deformation in excess of the permissible tolerance for the structure given in the Specifications. Falsework columns shall be supported on hardwood, concrete pads or metal bases to support all falsework that cannot be founded on rock, shale or thick deposits of other compact material in their natural beds. Falsework shall not be supported on any part of the structure, except the footings, without the written permission of the Engineer. The number and spacing of falsework columns, the adequacy of sills, caps and stringers and the amount of bracing in the falsework framing shall be subject to the approval of the Engineer.

C.2 All timber shall be of sound wood, in good condition and free from defects that might impair its strength. If the vertical members are of insufficient length to cap at the desired elevation for the horizontal members, they shall preferably be capped and frames constructed to the proper elevation. Ends of the vertical members shall be cut square for full bearing to preclude the use of wedges. If vertical splices are necessary, the abutting members shall be of the same approximate size, the ends shall be cut square for full bearing, and the splices shall be scabbed using a method approved by the Engineer.

C.3 The Contractor shall compute falsework settlement and deflection for bridges so that when the final settlement is complete, the structure will conform to the required camber, section and grade as shown on the Drawings.

C.4 The Contractor shall provide means for accurately measuring settlement in falsework during placement of concrete and shall provide a competent observer to observe and correct the settlement.

C.5 Screw jacks, if used, shall be designed for use with a slenderness ratio not exceeding 60. The slenderness ratio shall be taken as the ratio of the clear distance between effective bracing in both horizontal directions to the diameter of the screw jack measured at the root of the thread. The manufacturers' certificate showing the ultimate load capacity of the screw jack shall be submitted with the design calculations for the falsework. If directed by the Engineer, the Contractor shall furnish a test certificate carried out at an approved independent laboratory.

C.6 Props and towers supporting forms or partially completed structures shall be interconnected in plan orthogonally at levels to be determined in the design. They shall also be interconnected by diagonal bracings in orthogonal vertical planes.

5.04.5 FINISHES

A. Formed Finishes

A.1 **Class F1.** This class of surface finish denotes a special finish required from aesthetic considerations as shown on the Drawings. In addition to the requirements of Class F2 finish, the following additional requirements shall apply.

A.1.1 Finishes required on F1 surfaces shall be uniformly and consistently maintained with no variation in the colour or consistency of the concrete within the same structure. In order to achieve this, the Contractor shall make trial panels of the formed finishes specified. Panels shall be not less than 1.5 m high and 1 m wide and 250 mm thick and shall be cast in accordance with the method and materials as proposed for the actual Work.

A.1.2 The Contractor shall provide at his own expense as many panels as required by the Engineer until a satisfactory trial panel has been accepted by the Engineer. These shall include samples of piers, deck sections, retaining wall sections and/or underpass wall sections and typical precast edge unit to be cast on site using the same method as proposed for the prototypes. The Contractor shall submit to the Engineer and obtain his approval all details before commencement of trials. These samples, when approved, shall form the standard against which the corresponding finishes on the actual work will be judged. In all cases of approvals, the decision of the Engineer shall be final.

A.1.3 Samples and trial panels carried out at the place of manufacture to demonstrate to the Engineer that the forms and formliners and the methods of assembling and de-shuttering them are acceptable shall not be paid for and will not relieve the Contractor of the requirement for carrying out trial panels on site as described above.

A.1.4 If the required finish in the opinion of the Engineer, has not been obtained in the Works, the Contractor shall promptly carry out at his own expense all measures required by the Engineer to obtain the specified finish. These may include grit blasting followed by the application of polyester or epoxy paint. Where such remedial action is ordered by the Engineer, the entire exposed surface shall be so treated irrespective of whether or not the defective areas are localised or extensive.

A.2 **Class F2.** Formwork shall be lined with a material approved by the Engineer to provide a smooth finish of uniform appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing so that it imparts no blemishes. It shall be of the same type and obtained from only one source for any one structure. The Contractor shall make good any imperfections in the finish as directed by the Engineer. Internal ties and embedded metal parts shall not be permitted unless otherwise approved by the Engineer.

A.3 **Class F3.** Irregularities in the finish shall be no greater than those resulting from the use of wrought thick square edged boards arranged in a uniform pattern. The finish is intended to be left as struck. Imperfections such as fins and surface discoloration shall be made good as and when required by the Engineer.

A.4 **Class F4.** No special requirements.

A.5 Permanently exposed concrete surfaces to classes F1, F2 and F3 finish shall be protected from rust marks and stains of all kinds. Internal ties and embedded metal parts are not permitted.

A.6 The Contractor shall submit to the Engineer all details of formwork, liners, joints, and materials including fabrication drawings and stating procedures involved in the use of formwork for approval before commencement of any work on fabrication. No formwork shall be brought to site without the prior approval of the Engineer. Adequate time shall be allowed by the Contractor in his programme for these approvals after consultation with the Engineer.

B. Unformed Finishes

B.1 Class U1. The concrete shall be uniformly levelled and screeded to produce a plain or ridged surface as described in the Contract. No further work shall be applied to the surface unless is used as the first stage for Class U2 or Class U3 finish.

B.2 Class U2. After the concrete has hardened sufficiently, the concrete Class U1 surface shall be floated by hand or machine sufficiently to produce a uniform surface free from screed marks.

B.3 Class U3. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U1 surface shall be steel-trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

5.04.6 TOLERANCES

A. The tolerances in the forms and formwork shall be such that members formed shall be within the tolerances for the size and type of the member specified elsewhere in the Specification.

B. Falsework shall be fixed such that the completed structure shall be within the required tolerances in plan, elevation and slope for the size and type of structure specified elsewhere in the Specification.

C. Surfaces which are to receive deck waterproofing shall be finished to an accuracy such that when tested with a three meter long straight edge, the maximum depression shall not exceed five mm.

5.04.7 CONSTRUCTION REQUIREMENTS

A. The forms and falsework shall be inspected by the Engineer after assembly on the work area and immediately before concreting. No pour shall commence until the forms and falsework have been approved by the Engineer.

B. The inside surfaces of all forms shall, except for pavement formwork, or unless otherwise agreed by the Engineer, be coated with a release agent approved by the Engineer. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or prestressing tendons and anchorages. Only one type of release agent shall be used in formwork which will be visible in the finished work.

C. Immediately before concrete is placed, all forms shall be thoroughly cleaned.

D. Forms that are to be re-used shall be thoroughly cleaned and re-oiled and, if necessary, shall be reconditioned by revision or reconstruction. Unsatisfactory lumber shall be condemned by the Engineer and shall be removed from the Site.

E. Formwork shall be constructed so that the side forms of members can be removed without disturbing the soffit forms. If props are to be left in place when the soffit forms are removed, these props shall not be disturbed during the striking.

F. Runways used to move plant, equipment or materials shall be clear of the reinforcement and shall be robust enough not to deflect excessively or cause movement to the forms due to dynamic effects.

G. During concreting, the forms and their supports shall be constantly monitored for signs of imminent failure. Skilled operatives shall be in constant attendance during concreting who are qualified to make immediate adjustments to the forms and falsework so that concreting can satisfactorily be completed.

H. The Engineer shall suspend concreting operations if, in his opinion, the forms and falsework are in danger of failure and that the actions taken by the Contractor is insufficient or inadequate to guarantee the safe and satisfactory completion of concreting. In such an event, the Engineer shall instruct the Contractor to remove, at his expense, the concrete already poured.

I. If at any period of work, during or after placing of concrete, the forms show signs of sagging or bulging, the Contractor, at his own expense, shall remove the concrete to the extent directed by the Engineer, bring the forms to the proper position, and place concrete.

J. Immediately after the removal of the forms, all fins caused by form joints and other projections shall be removed and all pockets cleaned and filled with a cement mortar composed of 1 part by volume of Portland cement and 2 parts sand. Sufficient white Portland cement shall be mixed with the cement in the mortar, so that when dry the colour matches the surrounding concrete. Patches shall be moistened prior to mortaring to obtain a good bond with the concrete. When directed by the Engineer, the Contractor shall at his own expense, substitute an approved epoxy grout for the Portland cement mortar or provide an epoxy bonding agent to be used in conjunction with the Portland cement mortar. If, in the judgement of the Engineer, pockets are of such extent or character as to materially affect the strength of the structure or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of that portion of the structure affected. The resulting surfaces shall be true and uniform. Portions of the structure which cannot be finished or properly repaired to the satisfaction of the Engineer shall be removed.

5.04.8 REMOVAL OF FORMWORK AND FALSEWORK

A. To facilitate finishing, forms on handrails, ornamental work, and other vertical surfaces that require a rubbed finish, shall be removed as soon as the concrete has hardened sufficiently that it will not be injured, as determined by the Engineer. In determining the time for the removal of forms, consideration shall be given to the location and character of the structure, weather and other conditions influencing the setting of the concrete.

B. Formwork shall be removed without causing damage to the concrete and after sufficient time to allow for adequate curing and to prevent restraint that may arise from elastic shortening, shrinkage or creep.

C. Any remedial treatment to surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork and shall be carried out without delay. Any concrete surface which has been treated before being inspected by the Engineer shall be liable to rejection.

D. Where the concrete compressive strength is confirmed by tests on concrete cylinders (or cubes) stored under conditions approved by the Engineer, formwork supporting concrete in bending may be struck when the strength is 10 N/sq. mm or three times the stress to which it will be subjected, whichever is the greater.

E. For ordinary structural concrete made with ordinary Portland cement, in the absence of control cylinders (cubes) the period before striking shall be in accordance with the minimum periods given in Table 5.4.2 unless otherwise directed by the Engineer.

TABLE 5.4.2: MINIMUM PERIOD BEFORE STRIKING FOR STRUCTURAL CONCRETE MADE WITH ORDINARY PORTLAND CEMENT

Type of Formwork	**Minimum Period before striking at Surface Temperature of Concrete**		
	16°C	**7°C**	**t°C**
Vertical formwork to columns, walls and large beams	12 hours	18 hours	$\frac{300}{(t + 10)}$ hours
Soffit formwork to slabs	4 days	6 days	$\frac{100}{(t+10)}$ days
Props to slabs	10 days	15 days	$\frac{250}{(t+10)}$ days
Soffit to formwork to beams	9 days	14 days	$\frac{230}{(t+10)}$ days
Props to beams	14 days	21 days	$\frac{360}{(t+10)}$ days

5.04.9 MEASUREMENT

A. The provisions of this section of the Specification are not measured directly for payment but shall be considered subsidiary to the different classes of concrete described and measured for payment under the provisions of Section 5.01 "Concrete and Concrete Mixes and Testing" of the Specification.

B. Test panels carried out by the Contractor to demonstrate to the Engineer's satisfaction that the specified F1 finish can be achieved shall be measured for payment for the appropriate class of concrete measured for payment under the provisions of Section 5.01 "Concrete and Concrete Mixes and Testing" of the Specification. Test panels not accepted by the Engineer shall not be measured for payment.

C. Test samples, such as a section of retaining wall or a complete pier, carried out by the Contractor and approved by the Engineer for use as reference bench marks for the quality to be attained in the Works shall be measured for payment for the appropriate class of concrete measured for payment under the provisions of Section 5.01 "Concrete and Concrete Mixes and Testing". Test samples not accepted by the Engineer shall not be measured for payment.

SECTION 5.05: PLAIN AND REINFORCED CONCRETE STRUCTURES

5.05.1 SCOPE

This Section of the Specification describes the construction of plain and reinforced concrete structures.

5.05.2 MATERIALS

A. Concrete

Concrete shall be produced and supplied in accordance with Section 5.01: Concrete Mixes and Testing.

B. Reinforcement

Reinforcement shall conform to Section 5.03: Steel Reinforcement.

C. Formwork and Falsework

Formwork and Falsework shall be designed and supplied in accordance with Section 5.04: Formwork and Falsework.

D. Plant and Equipment

Plant and Equipment shall conform with the requirements of the Specifications Part 1 Section 4-4 and shall be the type and number outlined in the Contractor's detailed Programme of Works as approved by the Engineer.

5.05.3 CONSTRUCTION

A. General

A.1 The Contractor shall notify the Engineer his intention to concrete at least 24 hours in advance.

A.2 The Engineer shall check and certify that:

- The formwork meets the Specification requirements
- The falsework and support props are in accordance with the approved Drawings.
- The reinforcement conforms to the Drawings and that the correct cover has been provided
- The forms are free of dirt and other deleterious matter.

B. Concreting

Handling, placing and curing shall be in accordance with Section 5.02: Concrete Handling, Placing and Curing.

C. Slump

Slump shall be within the limits given in Section 5.02 of the Specification except that the maximum slump of bridge deck superstructure concrete shall be 75 mm, unless otherwise agreed by the Engineer.

D. Construction and Expansion Joints

D.1 Whenever placing of concrete is delayed until after the previously placed concrete has undergone initial set, the point of the break in pouring shall be deemed a construction joint. The location of construction joints shall be either as shown on the Drawings or planned in advance and the placing of concrete shall be carried out continuously from joint to joint. The joints shall be perpendicular to the principal lines of stress and at points of minimum shear unless otherwise agreed with the Engineer.

D.2 Where dowels, reinforcing bars or other ties are not indicated on the Drawings, keys shall be made by embedding water-soaked bevelled timbers in workable concrete. The keys shall be sized as detailed on the Drawings or as directed by the Engineer and shall be removed when the concrete has set. When resuming work the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance or other soft material with stiff wire brushes and, if deemed necessary by the Engineer, shall be roughened with a steel tool. The surface shall then be thoroughly washed with clean water and pointed with a thick coat of neat cement mortar, after which the concreting shall proceed.

D.3 Expansion joints shall be manufactured and installed in accordance with the Drawings or as approved by the Engineer.

E. Cold Joints

E.1 When the continuous placement of concrete in any structural member is interrupted or delayed for a period long enough for the previously partially placed concrete to take its initial set, the Engineer shall declare such a joint a cold joint in which case the Contractor shall immediately remove the previously partially placed concrete from the forms. No extra payment shall be made for the initial placement or the removal of concrete that is wasted because of a cold joint. The Engineer shall suspend all or any part of the subsequent concrete work until he deems the Contractor has corrected the cause for the cold joint occurrence.

E.2 The Engineer shall, in certain circumstances, allow the Contractor to retain the partially placed concrete and complete the concreting with a subsequent pour. If the Engineer allows a cold joint to be retained, the Contractor shall carry out, at his own expense, some or all of the following measures to the satisfaction of the Engineer before completing the pour:

E.2.1 Laitance shall be removed from the surface of the partially placed concrete without damage to reinforcement and formwork by wire brushing, light tooling or sand blasting as agreed with the Engineer.

E.2.2 Shear keys shall be cut in the partially placed concrete without damage to the reinforcement and formwork. The shape, size and orientation of the shear keys shall be as directed by the Engineer.

E.2.3 The cleaned surface of the partially placed concrete shall be coated with a bonding agent approved by the Engineer, before placing the subsequent pour.

E.2.4 Additives approved by the Engineer to facilitate bonding shall be added to the concrete used for the subsequent pour.

E.2.5 Dowel bars of a type and length to be approved by the Engineer shall be installed in the partially placed concrete using non-shrink cement grout or resin grout as directed by the Engineer. The size and spacing of the dowel bars shall be approved by the Engineer. Their installation shall not damage the reinforcement or formwork.

E.2.6 The partially placed and subsequently placed concrete shall be stressed using prestressing bars of a size and type approved by the Engineer to achieve a level of compressive stress at the interface approved by the Engineer. The method of installing the prestressing bars and type of anchors used shall be approved by the Engineer. Unless otherwise agreed with the Engineer, the drill hole shall be grouted with a cement grout containing expanding additive to the manufacturer's recommendations.

F. Finishing

F.1 Unless otherwise indicated in the Drawings or agreed by the Engineer, the following classes of finishes, as defined in Paragraph 5.04.05, shall be used for formed surfaces:

F.1.1 Pre-cast parapets, cladding panels, New Jersey Barriers, wall copings and other architectural features: **Class F1**

F.1.2 Exposed faces of retaining walls, abutments, piers, columns, bridge decks and box culverts not in contact with soil and which can be seen : **Class F2**

F.1.3 Backs of retaining walls and solid abutments, outer faces of box culverts, faces of abutment columns and bases of bank seats for spill-through abutments, plinths for columns, piers, lighting masts and sign gantries in permanent contact with soil: **Class F3**

F.1.4 Inner faces of box girders, cellular deck slabs, cellular bases and pile caps not in contact with earth and which are not visible: **Class F3**

F.1.5 Sides of bases, footings and pile caps permanently below finished ground level: **Class F4**

F.2 Unless otherwise noted in the Drawings, the following classes of finishes, as defined in paragraph 5.04.5, shall be used for unformed surfaces:

F.2.1 Tops of bases, footings, pile caps and box culverts, which are to be backfilled: **Class U1**

F.2.2 Top of walls and slab which are to receive coping or tiling: **Class U2**

F.2.3 Box culvert inverts, apron slabs of box culverts and tops of exposed walls and slabs: **Class U3**

F.3 Finish to bridge decks that are to receive an approved waterproof system shall initially be finished to Class U1. When the concrete has sufficiently hardened to prevent laitance being worked to the surface the surface shall be floated to produce a uniform surface free from screed marks and exposed aggregate. The surface shall then be textured by brushing or otherwise in accordance with the waterproofing manufacturer's requirements and as agreed with the Engineer. The accuracy of the finished surface shall be such that it does not deviate from the required profile by more than 10 millimetres over a 3 metre gage length or have any abrupt irregularities of more than 3 millimetres.

F.4 Surfaces, other than bridge decks, which are to receive approved waterproofing systems, shall be finished to Class U2, unless otherwise detailed on the Drawings or as instructed by the Engineer.

G. Concrete Cover to Reinforcement

G.1 The concrete cover to reinforcement shall be as shown on the Drawings. If no cover is detailed the cover shall be either the size of the bar or the maximum aggregate size, plus 5 mm, whichever is the greater. In the case of bundled bars, the cover shall be equal to or greater than the size of a single bar of equivalent area of the bundle plus 5 mm.

G.2 Where a surface treatment such as grooved finish or bush hammering cuts in to the face of the concrete, the depth of the treatment shall be added to the cover.

G.3 The cover to reinforcement shall take into account the concrete durability under the envisaged conditions of exposure. The minimum cover to reinforcement under such conditions shall be determined by Engineer on site.

H. Tolerances

H.1 In-Situ Construction

H.1.1 Length: The horizontal and vertical dimensions of in-situ concrete members, except cross-sections, shall be within the following tolerances:

Length (mm)	Tolerance (mm)
Up to 3000	± 3
3001-4500	± 6
Vertical lines out of plane	± 5 + 1 for every 3000 out of true line.

H.1.2 Cross-Section: Slab and wall thicknesses and the cross-sectional dimensions of beams, columns and piers shall be within the following tolerances:

Member Dimensions (mm)	Tolerance (mm)
Up to 500	6
501 -750	10
Additional for every subsequent 100 mm	±1 mm up to ±20 mm

H.2 Precast Construction

H.2.1 Length: The horizontal and vertical dimensions of precast members, except for cross-sections, shall be within the following tolerances:

Length (mm)	Tolerance (mm)
Up to 3000	± 2
3000 and over	± 5

H.2.2 Cross Section: Slab and wall thicknesses and the cross-sectional dimensions of beams, columns and piers, shall be within a tolerance of ± 3 mm.

H.3 Squareness

For in-situ and pre-cast construction the tolerance between the short side and the long side shall be within the following limits:

Member Size (mm)	Tolerance (mm)
Up to 3000	± 3
3000 and over	± 6

H.4 Straightness

For in-situ and precast construction the straightness or bow, defined as deviation from the intended line, shall be within the following tolerances:

Member Length (mm)	Tolerances (mm)
Up to 3000	± 3
3000 and over	± 6

H.5 Alignment

The alignment of members shall be within the following tolerances:

Column and piers: 1:400 of column or pier length.

Others: 1:600 of length.

H.6 Flatness

The flatness of a surface, measured with a 1.5 metre straight edge shall be not greater than 6 mm at any point.

H.7 Twist

Twist, measured as the deviation of any corner from the plane containing the other three corners, shall be within the following limits.

Member Length (mm)	Tolerance (mm)
Up to 6000	6
Above 6000	12

5.05.4 MEASUREMENT

The provisions of this Section of the Specification are not measured directly for payment but shall be considered subsidiary to the different classes of concrete described and measured for payment under the provisions of Section 5.01: Concrete and Concrete Mixes and Testing.

SECTION 5.06: WATERPROOFING FOR STRUCTURES

5.06.1 SCOPE

The work covered in this Section consists of furnishing and placing approved waterproofing membranes and damp-proofing courses to external concrete surfaces in contact with soil, furnishing and placing epoxy coatings to internal surfaces of concrete walls, slabs and beds and furnishing and installing waterstops to waterproof construction and expansion joints; all as shown on the Drawings or as directed by the Engineer.

5.06.2 MATERIALS

A. Asphalt

A.1 Waterproofing asphalt shall conform to the Specification for Asphalt for Dampproofing and Waterproofing, AASHTO M115 (ASTM D449). Type I asphalt shall be used below ground and Type II above ground.

A.2 Primer for use with asphalt in waterproofing shall conform to the Specification for Primer for Use with Asphalt in Dampproofing and Waterproofing, AASHTO M116 (ASTM D41).

B. Bitumen

B.1 Waterproofing bitumen shall conform to the Specification for Coal-Tar Bitumen for Roofing, Dampproofing and Waterproofing, AASHTO M118 (ASTM D450). Type II waterproofing bitumen shall be provided unless otherwise specified in the Drawings.

B.2 Primer for use with coal-tar bitumen in dampproofing and waterproofing shall conform to the Specification for Creosote for Priming Coat with Coal-Tar Pitch in Dampproofing and Waterproofing, AASHTO M121 (ASTM D43).

C. Fabric

Fabric shall conform to the Specification for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing, AASHTO M117 (ASTM D173).

D. Self-Adhesive Polyethylene Sheeting

Self-Adhesive Polyethylene Sheeting shall be flexible, preformed waterproof membrane comprising strong, high-density polyethylene film with a self-adhesive rubber/bitumen compound and having the following minimum properties:

- Total thickness : 1.5 mm
- Weight : 1.6 kg/m^2
- Tensile strength : 42 N/mm^2
- Elongation : 210% longitudinally; 160% transversely.
- Tear resistance : 340 N/mm longitudinally; 310 N/mm transversely.
- Puncture resistance: 220 N/ 65 mm

E. Tar for Absorptive Treatment

Tar for absorptive treatment shall be a liquid water-gas tar that conforms to the following requirements:

- Specific gravity, 25/25^{o}C 1.030 to 1.100
- Specific viscosity at 40^{o}C (Engler), not more than 3.0
- Total distillate, percent by weight, to 300^{o}C, not more than 50.0 %
- Bitumen (soluble in carbon disulphide) not less than 98.0 %
- Water, not more than 3.0 %

F. Tar Seal Coat

Tar seal coat shall conform to the Specification for Tar for Use in Road Construction, AASHTO M52, Grade RTCB-5 (ASTM D490).

G. Joint Fillers

Filler for use in horizontal and vertical joints in waterproofing work shall be a straight refined oil asphalt conforming to the following requirements:

- **Flash Point:** Not less than 232^{o}C.
- **Softening Point:** 48.9^{o}C to 54.4^{o}C.
- **Penetration:** At 0^{o}C, 200 grams, 1 minute, not less than 15.
  At 25^{o}C, 100 grams, 5 seconds, 50 to 60.
  At 46^{o}C, 50 grams, 5 seconds, not more than 300.
- **Loss on Heating:** At 163^{o}C, 50 grams, 5 hours, not more than 0.5 percent.
- **Ductility:** At 25^{o}C, 5 centimetres per minute, not less than 85.
- **Total Bitumen:** (soluble in carbon disulphide)**:** not less than 99.5 percent.

H. Waterstops

H.1 PVC Water Bars shall be extruded PVC, heavy duty, of the types and sizes shown on the Drawings, and complete with junction pieces.

H.2 Copper Water Stops shall be copper sheets of the thickness shown on the Drawings and shall conform to the requirements of AASHTO M138 (ASTM B152).

H.3 Plain Rubber Water Stops shall be formed from stock composed of a high grade compound made exclusively from new plantation rubber, reinforcing carbon black, zinc oxide, accelerators, anti-oxidants and softeners. This compound shall contain not less than 72 % by volume of new plantation rubber. The tensile strength shall be not less than 246 kg/cm^2, with an elongation at breaking of 550% when tested in accordance with ASTM D412. The unit stresses producing 300% and 500% elongation shall be not less than 77 kg and 198 kg/cm^2, respectively. The Shore Durometer indication (hardness) shall be between 55 and 65 when tested in accordance with ASTM D676. After 7 days in air at 126 ^{o}C (plus or minus 1 ^{o}C) or after 48 hours in oxygen at 126^{o}C (plus or minus 1^{o}C) both at 21kg/cm^2, the tensile strength and elongation shall not be less than 65 % of the original when tested in accordance with ASTM D572.

H.4 Synthetic Rubber Water Stops shall be formed from a compound made exclusively from neoprene, SBR, reinforcing carbon black, zinc oxide, polymerization agents and softeners. This compound shall contain not less than 70 percent by volume of neoprene or SBR. The tensile strength shall be not less than 175kg per square centimetre with an elongation at breaking of 425 % when tested in accordance with ASTM D412. The Shore Durometer Indication (hardness) shall be between 50 and 70 when tested in accordance with ASTM D676. After 7 days in air at 126 ^{o}C (plus or minus 1 ^{o}C) or after 48 hours in oxygen at 126 ^{o}C (plus or minus 1 ^{o}C) and 21kg kg/cm^2 pressure, the tensile strength shall be not less than 65 % of the original when tested in accordance with ASTM D572.

I. Proprietary Waterproofing Systems

Proprietary waterproofing systems shall be bituminous membranes reinforced with layers of suitable reinforcement, bituminous-coated polythene sheet, plasticized polyvinyl chloride sheet, other approved membranes or applications of resinous reinforced coatings. The type to be used shall be defined on the Drawings and shall be chosen according to its location and serviceability. The specific system shall be approved after site trials, should the Engineer decide these to be necessary.

J. Epoxy Coating System

An approved epoxy coating system shall be furnished and applied to the internal concrete surfaces of culverts and open channels as shown on the Drawings or as directed by the Engineer. The thickness of the epoxy coating shall be at least 400 (microns) in accordance with the manufacturer's recommendations.

5.06.3 SURFACE PREPARATION

A. Waterproofing

A.1 All concrete surfaces to be waterproofed shall be reasonably smooth and free from projections or holes which might cause puncture of the membrane. The surface shall be dry to prevent the formation of steam when the hot asphalt or tar is applied. Immediately before the application of the waterproofing, the surface shall be thoroughly cleaned of dust, projecting tying wire and loose material.

A.2 No waterproofing shall be carried out in wet weather or when the temperature is below 4 ^{o}C, without special authorisation from the Engineer. Should the surface of the concrete become temporarily damp, it shall be covered with a 2-inch (50mm) layer of hot sand, which shall be allowed to remain in place from 1 to 2 hours or sufficiently long enough to produce a warm and surface-dried condition, after which the sand shall be swept back, uncovering a sufficient surface for commencement of work and the operation repeated as the work progresses.

B. Dampproofing

The surface to which the damp-proofing coating is to be applied shall be cleaned of all loose and foreign material and dirt and shall be dry. If necessary, the Engineer shall instruct the surface to be scrubbed with water and a stiff brush, after which the surface shall be allowed to dry before application of the primer.

5.06.4 INSPECTION, DELIVERY AND STORAGE

A. All waterproofing materials shall be tested before shipment. Unless otherwise ordered by the Engineer, they shall be tested at the place of manufacture and, when so tested, a copy of the test results shall be sent to the Engineer by an agreed chemist or inspection bureau. Each package shall have affixed to it a label, seal, or other mark of identification, showing that it has been tested and found acceptable. The label shall identify the laboratory tests undertaken.

B. After delivery of the materials, representative check samples shall be taken which shall determine the acceptability of the materials.

C. All materials shall be delivered to the work in original containers, plainly marked with the manufacturer's brand or label.

D. Waterproofing and damp-proofing material shall be stored in a dry, protected place. Rolls of waterproofing fabric and membranes shall not be stored on end.

5.06.5 CONSTRUCTION

A. Asphalt and Bitumen Waterproofing Membranes

A.1 Asphalt shall be heated to a temperature between 150 ^{O}C and 175 ^{O}C and tar for hot application shall be heated to a temperature between 95 ^{O}C and 121 ^{O}C with frequent stirring to avoid local overheating. The heating kettles shall be equipped with thermometers.

A.2 In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed, so that water will run over and not against or along the laps.

A.3 The first strip of fabric shall be of half-width; the second shall be full-width, lapped the full-width of the first sheet; and the third and each succeeding strip shall be full-width and lapped so that there will be two layers of fabric at all points with laps not less than 5 cm wide. All end laps shall be at least 30 cm.

A.4 Beginning at the low point of the surface to be waterproofed, a coating of primer shall be applied and allowed to dry before the first coat of asphalt is applied. The waterproofing shall then be applied as follows.

A.5 Beginning at the low point of the surface to be waterproofed, a section of 50 cm wide and to the full length of the surface shall be mopped with the hot asphalt or tar and, immediately following mopping, the first strip or half width of fabric shall be carefully pressed into place eliminating all air bubbles. The applied strip and the adjacent section of the surface of a width equal to slightly more than half of the width of the fabric being used shall then be mopped with hot asphalt or tar and a full width of fabric applied, completely covering the first strip, and pressed into place. The second strip and an adjacent section of the concrete surface shall then be mopped with hot asphalt or tar and the third strip of fabric applied, lapping the second strip by at least 5 cm. This process shall be repeated until the entire surface is covered with each strip of fabric lapping at least 5cm over the previous strip. The entire surface shall then be given a final mopping of hot asphalt or tar.

A.6 The completed waterproofing shall be a firmly bonded membrane composed of two layers of fabric and three moppings of asphalt or tar, together with a coating of primer. All layers of fabric shall be separated or covered by layers of asphalt or tar.

A.7 Mopping on concrete shall cover the entire surface with no concrete showing and applied on cloth sufficiently heavy to completely conceal the weave. On horizontal surfaces, not less than 50 litres of asphalt or tar shall be applied for each 10m^2 of finished work, and on vertical surfaces not less than 60 litres per 10 m^2 shall be applied. The work shall regulated to ensure that at the close of a day's work, all cloth that is laid shall have received the final mopping of asphalt or tar. All laps shall be thoroughly sealed.

A.8 At the edges of the membrane and at any point where it is punctured by drains or pipes, suitable provision shall be made to prevent water ingress between the waterproofing and the waterproofed surface, to the satisfaction of the Engineer.

A.9 All flashing at kerbs and against girders, spandrel walls, etc. shall be applied using separate sheets overlapping the main membrane by at least 30 centimetres. Flashing shall be closely sealed either with metal counter-flashing or by the embedment of the upper edges of the flashing in a groove full of joint filler.

A.10 Open joints other than expansion joints shall be caulked with oakum and lead wool and then filled with hot joint filler.

A.11 Expansion joints, both horizontal and vertical, shall be provided with sheet copper or lead in "U" or "V" forms in accordance with the Drawings. After the membrane has been placed, the joint shall be filled with hot joint filler. The membrane shall be carried continuously across all expansion joints.

A.12 At the ends of the structure the membrane shall be carried down on the abutments and suitable provision made for all movement.

B. Proprietary Waterproofing Membranes

Proprietary waterproofing membranes shall be installed strictly in accordance with the manufacturer's instructions and shall be laid so that no air is trapped between it and the concrete surface or between successive layers of sheeting. Unless otherwise specified, joints between sheets shall be lapped with end laps of at least 150 mm and side laps of at least 100 mm. The joints shall be arranged so that there are no more than three thicknesses of sheeting and so that water will drain away from the exposed edge.

C. Damage Patching of Waterproofing Membranes

C.1 Finished membranes shall be protected against damage and unnecessary contact. Any damage shall be repaired by patching. Patches shall extend at least 300 mm beyond the outermost damaged portion and the second application shall extend at least 75 mm beyond the first.

C.2 Proprietary waterproofing membranes shall be repaired according to the manufacturer's specifications and as directed by the Engineer.

D. Dampproofing

D.1 Concrete, brick or other surfaces to be protected by dampproofing shall be thoroughly cleaned before the primer is applied. Surfaces shall then be brush- or spray-painted with two or more coats of tar or asphalt for absorptive treatment as indicated on the Drawings or instructed by the Engineer. Dampproofing below ground level shall consist of not less than two coats at an application rate of 0.6 litres per square metre per coat. Above ground level one application of tar or asphalt seal coat shall be applied by brush, at an application rate of 0.5 litres per square metre.

D.2 Paints shall be applied to the areas to be waterproofed only. Any disfigurement of any other parts of the structure by dripping or spreading of the tar or asphalt shall be cleaned at the Contractor's expense to the Engineer's approval.

E. Protection of Waterproofing and Dampproofing

E.1 The waterproofing membrane and dampproofing courses shall be protected by a 50 mm course of mortar mixed in the proportion of one part Portland cement and two parts sand, unless otherwise shown on the Drawings. This mortar course shall be reinforced midway between its top and bottom surfaces with wire netting of 0.15m mesh and No. 12 gauge, or its equivalent. The top surface shall be trowelled to a smooth, hard finish true to grade.

E.2 The construction of the protection course shall follow the application of waterproofing within 24 hours.

E.3 Unless otherwise shown on the Drawings or directed by the Engineer, vertical faces either waterproofed or dampproofed shall be protected by a porous concrete block wall of not less than 225mm thickness or a proprietary synthetic sheeting if approved by the Engineer.

F. Water Stops

F.1 **Copper Water Stops:** Copper sheets for water stops shall be of the width specified and shall be bent to the shapes shown on the Drawings or instructed by the Engineer. The sheet copper in each joint shall be continuous; separate pieces being connected by thoroughly workmanlike soldered joints to form a complete watertight unit. The sheet copper shall be placed to ensure its embedment in the concrete on each side of the joint in the positions shown on the Drawings.

F.2 **Rubber Water Stops:** Rubber water stops shall be installed in accordance with the details shown on the Drawings. The water stops shall be formed with an integral cross section which shall be uniform within 3mm in width and the web thickness or bulb diameter, within plus 1.5mm and minus 0.75mm. No splices shall be permitted in straight strips. Strips and special connection pieces shall be well cured and all cross sections shall be dense, homogenous and free from all porosity. All junctions in the special connection pieces shall be fully moulded. During the vulcanizing period the joints shall be securely held by suitable clamps. The material at the splices shall be dense and homogenous throughout the cross section. Field splices shall be either vulcanized, mechanical, using stainless steel parts or made with a rubber splicing union of the same stock as the water stop. All finished splices shall demonstrate a tensile strength of not less than 50 % of the unspliced material.

G. Testing

Unless otherwise agreed by the Engineer, at least one site trial application of the waterproofing system shall be carried out to determine the suitability of the surface preparation, method of application and effectiveness of the protective layer. The size of membrane laid shall be not less than 2.0 metres wide and 5.0 metres long.

5.06.6 MEASUREMENT

A. Waterproofing membrane shall be measured by the square metre laid, completed and accepted for different types of waterproofing membranes.

B. Tar or bituminous painting to surfaces permanently in contact with backfilled material shall be measured by the square metre of surface area so painted, irrespective of the number of coats of paint specified.

C. Water stops shall not be measured for direct payment but shall be deemed to be included in the rates for concrete.

D. Protection to waterproofing membrane and dampproofing courses shall not be measured for direct payment but shall be deemed to be included in the rates for waterproofing and dampproofing.

E. Site trials of waterproofing membranes shall not be measured for direct payment but shall be deemed to be included in the rates for waterproofing.

F. The amount of completed and accepted work measured as provided above shall be paid at the unit price bid as specified in the Bill of Quantities; these prices shall be full compensation for furnishing all materials, labour, equipment, tools, supplies and all other items necessary for the completion of the work.

SECTION 5.07: JOINTS, SEALERS AND FILLERS

5.07.1 SCOPE

This work covered in this Section consists of joint sealing materials and preformed expansion joint filler for use as and where shown on the Drawings or as directed by the Engineer.

5.07.2 MATERIALS: JOINT SEALING COMPOUNDS

A. Hot Type Joint Sealing Compounds

A.1 Composition

This type shall be a mixture of virgin synthetic rubber or reclaimed rubber, or a combination of the two, with asphalt plasticizers. Ground cured rubber scrap shall not be used.

A.2 Physical Requirements

A.2.1 The joint sealing compound, after heating and application, shall form a resilient and adhesive compound capable of effectively sealing joints in concrete against the infiltration of moisture and foreign material through repeated cycles of expansion and contraction. It shall be capable of being brought by heating to a uniform, smooth pouring consistency, free from lumps, and suitable for completely filling the joints without damage to the material. It shall not flow from the joints or be picked-up and tracked by vehicle tyres in summer temperatures.

A.2.2 The application temperature shall be at least 11 ^{o}C lower than the safe heating temperature. The safe heating temperature is defined as the highest temperature to which the material can be heated and still meet all requirements of the Specification. No sample of the material shall be tested until the manufacturer furnishes his recommended safe-heating and pouring temperatures.

A.2.3 **Prolonged Heating:** After 6 hours of continuous heating, with constant mixing in the laboratory at the manufacturer's recommended pour temperature, the joint sealer shall meet all requirements of the Specification.

A.2.4 **Penetration:** The penetration at 25 ^{o}C, 150 g, 5 sec, shall not be less than 50 or more than 90 mm.

A.2.5 **Flow:** The flow at 60 ^{o}C and at a 75-degree angle shall not exceed 1 cm in 5 hours.

A.2.6 **Ductility:** Ductility at 25 ^{o}C shall be not less than 35 cm.

A.2.7 Bond: The hot type joint sealing compound material when tested at minus 17.8 ^{o}C to 100 percent extension (1.27 cm extended to 2.54 cm) shall, after 5 cycles, show no surface checking, cracking, separation or other opening in the material or between the material and the block. At least 2 test specimens in a set of 3 specimens representing a given sample shall meet this requirement.

A.2.8 Resilience: Recovery shall be not less than 25 percent.

A.2.9 Compression recovery: Compression recovery of bond specimens shall be not less than 1 cm within 15 min.

A.2.10 Impact: No failure in cohesion or adhesion shall occur.

A.3 Methods of Sampling and Testing

A.3.1 Sampling: Samples for testing shall consist of not less than a 4.5 kilogram sample from each batch of the joint sealer. A batch shall be considered as all finished material manufactured simultaneously or continuously as a unit between the time of compounding and the time of packaging or placing in shipping containers. Each package or container shall be marked properly to indicate clearly the batch of which it forms a part. The material shall be sampled in accordance with the requirements of the "Standard Methods of Sampling Bituminous Materials" (ASTM Designation: D140) for solid materials in cakes.

A.3.2 Testing: Testing shall be in accordance with AASHTO T187 except that the tolerances on dimensions of test specimens, Article 6.3, shall be $\pm$ 0.13 cm and the temperature tolerances, Article 6.4 shall be $\pm$ 2.2 ^{o}C.

B. Cold Type Joint Sealing Compounds

B.1 Composition

Cold type material shall be homogeneous and of such consistency that it can be applied by high-pressure pumps through suitable nozzles to completely fill the joints. The compound may be blended with a suitable solvent or solvents by the manufacturer to provide better workability during installation in the joints. The solvents shall be sufficiently volatile that they will evaporate within a short time after installation leaving a material that is adhesive and resilient.

B.2 Physical Requirements

B.2.1 Flow: The flow during a 5-hour period at 60 ^{o}C shall not exceed 0.5 cm.

B.2.2 Penetration: After evaporation of the solvent, the penetration at 25 ^{o}C, 150 gm, 5 sec, shall not exceed 220 mm.

B.2.3 Bond: When the compound is tested at minus 17.8 ^{o}C, the development at any time during the test procedure of a crack, separation or other opening which is at any point over 64 mm deep in the material or between the material and the concrete block, shall constitute failure of the test specimen. The failure of more than 1 test specimen in a group of 3 specimens, representing a given sample of joint sealing compound shall be cause for rejection of the sample.

B.3 Methods of Sampling and Testing

Cold-type joint compounds shall be tested in accordance with ASTM D1851, except that material for test specimens (Article 7(c)) shall be stirred manually rather than mechanically.

B.4 Preformed Joint Seals

Preformed Polychloroprene Elastomeric Joint Seals shall comply with the requirements of AASHTO M220 (ASTM D2628).

C. Movement Joints in Water Retaining Structures

Joint sealants for movement joints in water retaining structures shall be polysulphide based compounds to BS EN ISO 11600:2003 and approved by the Engineer.

D. Exposed Joint Sealants for Movement Joints

Exposed joint sealants for movement joints shall be polysulphide rubber based compounds unless otherwise specified and subject to approval by the Engineer.

E. Backing Strips for Movement Joints

Backing strips shall be of a type recommended by the joint sealant manufacturer and approved by the Engineer.

5.07.3 PREFORMED EXPANSION JOINT FILLER

A. Description

Preformed expansion joint filler shall be a non-extruding and resilient bituminous type and shall have relatively little extrusion and a moderate to high amount of recovery after release from compression.

B. Requirements

Non-extruding and resilient types of expansion joint filler shall conform to all the requirements of the Standard Specification for "Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)", AASHTO Designation M213 (ASTM D1751).

C. Movement Joint Sheet Material Filler in Water Retaining Structures

Expansion joints in water retaining structures shall be bonded granular cork to ASTM D1752 or ASTM D1751 and as approved by the Engineer.

5.07.4 CERTIFICATE OF GUARANTEE

The Contractor shall furnish the Engineer with a Manufacturer's Certificate of Guarantee for each type of joint material delivered to the Site. The certificate shall note compliance to the appropriate specifications and shall state the results of the tests performed on the material, as required by the specifications. The Contractor shall, when so directed by the Engineer, have the joint material tested for conformance to the applicable specifications at an approved testing laboratory. All costs connected with Certificate of Guarantee and any subsequent quality testing shall be at the Contractor's expense.

5.07.5 CONSTRUCTION

A. Joints shall be straight, vertical, horizontal or as detailed on the drawings or approved by the Engineer. Joints shall be formed to accommodate any projecting reinforcement.

B. Movement Joints are either:

- Formed expansion joints
- Formed contraction joints
- Induced contraction joints.

C. Formed movement joints shall be constructed between rigid stop ends and formwork at formed movement joints to permit separate construction of structurally separate parts of the work.

D. The Contractor shall submit proposals for the positions of construction joints, where they are not coincident with movement joints, for approval by the Engineer.

E. To prepare for construction joints the face shall be lightly roughened to expose coarse aggregate unless otherwise instructed by the Engineer. The face shall be wetted and covered with a 1:1 cement and sand grout immediately prior to placing fresh concrete. Roughening shall not take place in areas less than 25 mm from arrises to surfaces exposed to view in the finished work. Small mortar lips shall be removed from exposed arrises using a carborundum stone. The face shall be clean and damp before fresh concrete is placed against it.

F. Side and end forms of concrete floors shall be square edged to the steel top surface.

G. External waterbars shall be nailed to forms prior to concreting and butt jointed in accordance with the manufacturer's instructions.

H. Movement joints shall be sealed strictly in accordance with the manufacturer's recommendations. Joints shall be thoroughly clean and dry, free from oil and loose material. Joint faces shall be wire brushed or grit blasted and cleaned out with compressed air. The joint faces shall then be allowed to dry. Exposed faces shall be have their edges masked with tape before priming and the tape removed immediately after sealing. Sealant shall be applied to ensure a maximum adhesion to the sides of the joints and a neat, smooth and clean finish.

5.07.6 MEASUREMENT

A. No part of this Section is a Bid Item and no measurement shall be made.

B. The materials provided for this Section will not be paid for directly, but will be considered included in the payment for other items of work appearing in the Bill of Quantities.

SECTION 6: INCIDENTAL CONSTRUCTION

SECTION 6: INCIDENTAL CONSTRUCTION

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SECTION 6.01 CONCRETE KERBS, GUTTERS, SIDEWALKS AND PAVED MEDIANS

6.01.1 SCOPE

The works covered in this Section consists of furnishing materials and construction of concrete kerbs, gutters, kerb-and-gutter combinations and concrete paving to sidewalks and medians, using in-situ or precast concrete as and where shown on the Drawings.

6.01.2 MATERIALS AND PRECAST MANUFACTURE

A. Concrete

Portland cement concrete shall be Class 210/20 for all in-situ and precast concrete, except for base course and backing concrete which shall be Class 110/25. All concrete shall conform to the relevant requirements of Section 5.01: Concrete Mixes and Testing and shall be produced by commercial ready-mix plant approved by the Engineer.

B. Mortar

Mortar shall consist of cement and fine aggregate having the same proportions as used in the concrete construction and shall conform to all relevant requirements of Section 5.01: Concrete Mixes and Testing.

C. Reinforcement

Reinforcing steel shall conform to the requirements of Section 5.03: Steel Reinforcement.

D. Precast Concrete Units

D.1 All precast units shall be manufactured to the dimensions shown on the Drawings. Manufacturing tolerances shall be 3 mm in any one dimension. End and edge faces shall be perpendicular to the base.

D.2 Each precast kerb or gutter unit shall normally be 0.5 m in length and this length shall be reduced to 0.25 m or as directed, where units are to be installed along curves of less than 10 m radius.

D.3 For horizontal curves of radius less than 10 metres, kerb and gutter units shall be manufactured to the radius shown and in such circumstances straight elements or portions of straight elements shall not be used. Bullnoses and curved faces shall be of constant radius with a smooth transition from a radius to a plain face.

D.4 Unless shown otherwise on the Drawings, precast concrete tiles (paving slabs) shall be 400 mm by 400 mm by 40 mm thickness with a 5 mm edge bevel. The tile face shall be grooved in squares of a size agreed by the Engineer as appropriate to the tile dimensions. Colouring of the top layer, where required, shall be achieved using mineral oxides.

D.5 Surfaces of precast units that will be exposed to view after installation shall be true and even, with a dense finish of uniform texture and colour, free from cracks, holes, fins, staining or other blemishes or defects. Units failing to meet these requirements shall be rejected. Surfaces that will not be exposed to view after installation shall have all fins and irregular projections removed and all cavities, minor honeycombing and other defects made good with mortar after the units have been saturated with water for at least 3 hours.

D.6 Precast units shall be cast upside down in approved steel moulds under conditions of controlled temperature and humidity. The units shall be steam cured or any other method approved by the Engineer until the concrete attains the full specified 28-day strength.

D.7 The Contractor shall submit for approval, samples of each of the proposed units together with the manufacturer's certificates and details of the method of manufacture and materials to be used. The Engineer's approval of the samples shall not be considered final and the Engineer shall reject any precast units delivered to the Site, which do not meet the required standards.

D.8 Testing of Tiles

The following tests shall be carried out on sidewalk tiles to ascertain their suitability for the work.

(i) Flexural Strength

(ii) Abrasion Resistance

The first test shall be carried out on four samples taking as the final result the average of the most homogeneous results of the four. The abrasion resistance test shall be carried out on two samples, the results of which shall be averaged.

(i) Flexural Strength

This test shall be carried out by placing the tile on two knife edge supports, with edges rounded with a radius of one cm, arranged parallel to the side of the tile and ten cm apart. The load is gradually transmitted to the tile top surface along the centreline by a third knife edge arranged parallel to the other two.

The unit maximum bending stress (Flexural Strength) equals $15Phb^2$ where "P" is the total breaking load in kilograms, "b" is the width of the tile in centimetres, "h" the thickness of the tile in centimetres.

The minimum value for Flexural Strength shall be 30 kg/sq. cm minimum.

(ii) Abrasion Resistance

This test is carried out with a machine composed of a horizontal cast-iron disc, rotating about its vertical central axis at uniform speed; a horizontal diametrical cross-piece by which two samples are pressed on the disc, at such a distance from the centre of the disc, that the relative speed with respect to the disc, is one metre per second; a second horizontal diametrical cross-piece orthogonal to the first, which carries at either end appropriate devices to let the moistened abrasive flow on the track; two pairs of conveniently arranged brushes to guide the abrasive that tends to escape under the samples.

The samples, pressed against the disc, rotate by means of a special mechanical device, around their own vertical central axis, at the rate of one turn of the specimen for 50 turns of the disc. Carborundum grit sufficiently coated with liquid mineral oil with an Engler viscosity of between five and seven at 50^oC shall be used as an abrasive. The grit shall pass sieve No. 60 and be retained on sieve No. 100. Consumption of carborundum and oil shall be approximately 20 and 12 grams respectively per minute.

The square sample, with a surface area of 50 sq. cm shall be pressed against the disc by a total weight of 15 kg (unit pressure of 0.3 kg/sq. cm). The test shall be carried out with a distance run of the grinding wheel of 500 meters. For materials with a surface wearing layer different from the rest of the tile, the distance run shall be such that the disc does not penetrate into the lower layer.

The thickness of the layer abraded in mm with a pressure of 0.3 kg/sq. cm for a distance run of 1000 meters is taken as the abrasion factor. This factor is determined by assuming that the consumption is proportional to the distance run.

The limit acceptance value for the Abrasion Factor shall be 12mm maximum.

E. Preformed Expansion Joint Filler

Preformed expansion joint filler shall conform to AASHTO M 33.

F. Epoxy Adhesive

Epoxy adhesive (for use in attaching precast units to existing concrete pavement surfaces) shall conform to the relevant requirements of Section 6.10: Raised Pavement Markers.

G. Ducts

Ducts (if required under sidewalks or medians) shall consist of uPVC plastic pipe conforming to ASTM D 2750, Type II. If jacking is required, duct shall be galvanized steel tube approved by the Engineer.

H. Bedding

Bedding material shall conform to the relevant requirements of Section 3.02: Granular Sub-Base Courses for Class A or Class B Granular Material.

6.01.3 CONSTRUCTION AND INSTALLATION

A. Cast In-Situ Curbs and Gutters

A.1 The subgrade shall be excavated to the grades and sections shown on the Drawings. If the section is not indicated, the width to be excavated shall be 300 mm each side of the outside edges of the kerb or gutter. The subgrade shall be of approved uniform density. The subgrade shall be excavated to a minimum depth of 150 mm below base level and the material replaced with bedding material which shall be compacted to at least 95% AASHTO T180 maximum density. All foundations shall be rolled or compacted to provide a smooth surface and shall be approved before placing concrete.

A.2 For stationary side form construction forms for kerbs and gutters shall be of a proprietary steel type. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finish in accordance with the dimensions, lines and grades required. Forms shall be cleaned and oiled before each use. Forms shall be removed as soon as practicable after concreting, provided no damage results to the kerb or gutter and not until at least 24 hours after completion of concreting.

A.3 For slip-form construction, kerbs or gutters shall be constructed by use of either slip-form or extrusion equipment. The completed kerb or gutter shall be true to shape, grade, and line and the concrete shall be compacted and of the required surface texture.

A.4 Concrete shall be placed upon the previously prepared and moistened subgrade and compacted with an internal vibrator. The surface shall be shaped by use of a steel screed to produce the section shown on the Drawings. The edges shall be rounded with preformed shuttering to form the required radius, which, if not shown otherwise on the Drawings, shall be 5 mm.

A.5 Contraction and construction joints of the required types shall be constructed at the intervals and locations shown on the Drawings. Adjacent to flexible base or surface courses, weaker plane contraction joints in curbs or gutters shall be constructed by sawing through the kerb to a depth of not less than 30 mm below the surface of the gutter, by inserting a suitable removable metal template in the fresh concrete or by other methods if approved before construction by the Engineer. Sealing of joints shall not be required unless shown on the Drawings.

A.6 Exposed surfaces shall be finished to the full width with a trowel and edger. The top face of kerbs or gutters shall receive a light brush finish. Forms for the roadway face of kerbs and the top surface of gutters shall be removed not less than 24 hours after the concrete has been placed. Finishing of the surfaces shall then be carried out provided the alignment tolerances and other requirements have been met.

A.7 Tolerances on tangential sections of kerbs and gutters shall be tested using a 4 m straightedge. The finished surface of concrete shall not deviate from the straightedge between any 2 contact points by more than 5 mm. Curved sections shall be true to the specified radius plus or minus 5 mm and all joints shall be flush and neat in appearance.

A.8 All fins and irregular projections shall be removed and cavities produced by form ties and all other small holes, honeycomb spots, broken corners or edges and other defects shall be rectified. After saturating with water for a period of not less than 3 hours, the surfaces shall be carefully pointed and made true with mortar. All construction and expansion joints shall be left carefully tooled and free of all mortar and concrete. Joint filler shall be left exposed for its full length with clean and true edges. The resulting surfaces shall be true and uniform.

A.9 A rubbed finish shall then be carried out to surfaces, which are to be exposed to view after completion of construction. Before rubbing, the concrete shall be kept saturated with water for at least 3 hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of holes and defects to set. Surfaces shall be rubbed with a medium carborundum stone, using mortar on its face. Rubbing shall remove all remaining form marks, projections and irregularities and result in a uniform surface. The final finish shall involve rubbing with a fine carborundum stone and water until the entire surface is of a smooth texture and uniform colour. After the surface has dried, loose powder shall be removed and the surface shall be left clean and free from unacceptable flaws or imperfections.

A.10 Kerbs and gutters shall be moist cured until stripped and finished, and then membrane cured in accordance with the relevant requirements of Section 5.02: Concrete Handling, Placing and Curing. Curing compound shall be applied immediately following completion of the rubbed finish.

A.11 The area adjacent to completed and accepted kerbs and gutters shall be backfilled with approved material to their top edges or to the elevations shown on the Drawings. Backfill shall be placed and compacted to 95% AASHTO T180 maximum density.

B. Precast Concrete Kerbs and Gutters

B.1 Subgrade for the concrete base shall be constructed as for in-situ kerbs and gutters.

B.2 Forms for the concrete base shall be wood or steel. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finished product correct to the dimensions, lines and grade required. Forms shall be cleaned and oiled before each use. If approved beforehand by the Engineer, forms for the concrete base may be omitted and the concrete placed directly against undisturbed excavated faces.

B.3 Base concrete shall be placed, compacted and shaped to the sections shown on the Drawings. Concrete shall be compacted to the satisfaction of the Engineer with an internal type vibrator or by manual means. Edges shall be rounded if necessary by the use of wood moulding or by the use of an edger as applicable. The concrete base shall be finished to a true and even surface with a wood float. Concrete shall be membrane or water cured for at least seven days before precast units are placed thereon.

B.4 Precast units shall be soaked in water immediately before installation. Units shall be set accurately in position in mortar on the concrete base. Joints between precast units shall not be mortared unless otherwise shown on the Drawings. Units shall be closely spaced and expansion joints provided every 10 metres.

B.5 Where kerbs or gutters are installed on existing concrete pavement using epoxy resin adhesive, the installation procedures shall conform to those specified for raised pavement markers in Section 6.10: Pavement Markings for Traffic.

B.6 After kerbs have been installed concrete backing shall be placed as shown on the Drawings. Pavement courses shall not be laid against curbs until the concrete backing has been membrane or water cured for at least 14 days.

B.7 The tolerances on the alignment of completed precast units shall be as specified for in-situ concrete construction.

B.8 Backfilling shall be carried out as specified for in- situ kerbs and gutters.

C. In Situ Concrete Paving

C.1 Excavation shall be carried out to the required depth and to a width that shall permit the installation and bracing of the forms. The foundation shall be shaped and compacted to an even surface conforming to the sections shown on the Drawings. All soft and yielding material shall be removed and replaced with suitable fill material.

C.2 Bedding material shall be placed in layers not exceeding 100 mm in depth and each layer shall be compacted to 95% AASHTO T180 maximum density. The total bedding course thickness shall be as shown on the Drawings, or if not shown, 100 mm minimum thickness.

C.3 Forms shall be of steel or wood and shall extend for the full depth of the concrete. All forms shall be straight, free from warping and of sufficient strength to resist the pressure of the concrete without displacement. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. All forms shall be cleaned and oiled before concrete is placed.

C.4 The formation shall be thoroughly moistened immediately prior to the placing of concrete. Concrete shall be deposited in one course without segregation and shall be compacted by vibrators. The surface shall be finished with a wooden float and light brooming. No plastering of the surface shall be permitted. All outside edges of the tiles and all joints shall be edged with a 5 mm radius edging tool.

C.5 Forms shall only be removed when there is no risk of damage to the concrete and at least 24 hours after completion of concreting.

C.6 The smoothness of paved areas shall be tested using a 4 m straightedge. The finished surface of concrete shall not deviate from the straightedge between any two contact points by more than 5 mm. Sections of defective paving shall be removed and replaced as directed by the Engineer at the Contractor's expense.

C.7 Expansion joints shall be of the dimensions specified and shall be filled with approved, premolded expansion joint filler. The area being paved shall be divided into sections by weakened plane joints formed by a jointing tool or other methods acceptable to the Engineer. Joints shall extend into the concrete 0.20 to 0.25 times the depth and shall be approximately 3 mm wide. Joints shall match as nearly as possible adjacent joints in curb or pavements. Weakened plane joints may be sawn in lieu of forming with a jointing tool.

C.8 Construction joints shall be formed around all appurtenances such as manholes or utility poles, extending into and through the sidewalk or median. Premolded expansion joint filler of 10 mm thickness shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete construction and any adjacent fixed structures such as walls, buildings or bridges. The expansion joint material shall extend for the full depth of the concrete.

C.9 Concrete shall be cured by membrane curing in accordance with the requirements of Section 5.02: Concrete Handling, Placing and Curing.

D. Precast Concrete Tiles (Paving Slabs)

D.1 Excavation and placing of bedding material shall be as specified for in-situ concrete paving. The surface of the completed bedding shall be dampened and base course concrete placed and finished to the thickness as shown on the Drawings or, if not shown, 40 mm minimum thickness.

D.2 Base course concrete shall be water or membrane cured as specified for in situ concrete paving, for a period of not less than 7 days before placing precast tiles.

D.3 Immediately prior to tile laying, the concrete base course shall be dampened and the concrete tiles shall be immersed in water. Tiles shall then be laid true to line and grade on a 10 mm to 20 mm thickness of mortar. Joints shall be 3 mm wide.

D.4 The tolerance on smoothness of precast concrete tiled areas and removal and replacement of defective tiling shall be as specified for in situ concrete paving.

D.5 Tiles shall be cleaned 24 to 36 hours after laying and joints shall be mortared using a plasticizer in the mortar to improve workability and to enable the mortar to be readily smoothed and finished. As soon as the mortar has partially set, all mortar material shall be raked from the top 3 mm depth of the joint, using a grooving tool to produce a smooth circular section.

D.6 When the mortar is sufficiently set, the surface shall be sprinkled with water and covered with plastic or nylon sheets during the curing period. The sheets shall be left in place until final hardening of the mortar or as directed by the Engineer. All foreign matter, wood, concrete, mortar lumps, etc., shall then be removed and the surface cleaned of staining, discolouration and other blemishes.

D.7 In cases where tiles are required to be cut at the boundaries of tiled areas, or due to the presence of obstacles, poles, hydrants, etc., or in the construction of the driveways or side roads, the Contractor shall cut the tiles or substitute in situ concrete of at least the same quality as the tile concrete. The Engineer shall decide, after trials, on the method to be adopted. Cutting of tiles or substitution of in-situ concrete shall be kept to a minimum. The Contractor shall complete the areas using uncut precast tiles to the maximum extent practicable.

D.8 The method of construction and sequence of operations for areas constructed using precast tiles shall be the same as for areas constructed using in situ concrete. The Contractor shall ensure that the final appearance of such surfaces, regardless of the method of construction, is substantially the same for all types of construction.

D.9 Where a sidewalk crosses the entrance to a shop or a house, etc., which is higher than the sidewalk, the Contractor shall construct steps, formed by a curb and a complete or partial tile. Steps shall be backfilled with concrete of the same quality as specified for concrete base course.

D.10 Steps shall be constructed wherever the difference in elevation between the entrance and the sidewalk is more than 250 mm. The Contractor shall submit for approval, prior to commencing any sidewalk construction, a list of locations where steps are required, together with design details for their construction.

6.01.4 MEASUREMENT

A. Precast Concrete Kerbs and Gutters shall be measured by the linear metre of each type furnished, constructed or installed, completed, and accepted. Measurements shall be taken on the front face of concrete curbs or on the flow line of gutters as appropriate and shall include measurement of concrete kerbs required for steps.

B. Precast Concrete Edge Kerb and In Situ Concrete Edge Curb shall be measured by the linear metre of each type furnished, constructed or installed, completed and accepted.

C. Precast Concrete Tiling shall be measured by the square metre of the plan area of each type furnished, constructed or installed, completed, and accepted.

D. Excavation, backfilling, bedding, concrete base course, concrete backing, construction in and around obstacles, poles, manholes, flower beds, cutting and shaping of tiles on curves, jointing, and finishing at walls and fences, etc., shall not be separately measured for direct payment, but shall be considered as subsidiary work; the costs of which will be deemed to be included in the Contract Prices for the Pay Items.

SECTION 6.07 MAINTENANCE OF TRAFFIC AND DETOURS

6.07.1 SCOPE

A. The work covered in this section includes the supply of all materials, construction of detour roads, bridges and culverts where necessary and installing, operating and maintaining all required temporary lighting, signing, signals, pavement marking, barriers and other safety measures for the maintenance of vehicular and pedestrian traffic through and around the Site of the Works during the Contract Period. These works also include the removal of all unwanted temporary detour items and facilities at the end of the Contract and other work as directed by the Engineer.

6.07.2 MAINTENANCE AND PROTECTION OF TRAFFIC

A. General Procedures

A.1 The Contractor shall ensure the free movement of vehicular and pedestrian traffic and shall maintain all highways including temporary detours and accesses in a clear and safe condition free from obstructions. Adequate access to the Site shall be maintained at all times to ensure that traffic on existing roads is not impeded unnecessarily by traffic turning into the Site.

A.2 In order to facilitate movement of traffic through or around construction and when and wherever required by the Engineer, the Contractor shall furnish, erect and maintain signs, traffic barricades and other facilities necessary for safe and efficient direction and handling of traffic at specified locations in or around the Site to the satisfaction and approval of the Engineer.

A.3 The Contractor shall, if detailed on the Drawings or instructed by the Engineer, provide flashing signal lights by night and provide sturdy barricades for the protection of workmen engaged on traffic control.

A.4 Where required by the Contract Documents or the Engineer, the Contractor shall provide, erect, operate and maintain temporary traffic signals of the 3-colour type. Signals shall be capable of both automatic and manual operation as required. The timing device of any automatic traffic signal shall be accurate to within plus or minus two seconds.

A.5 Manually operated "stop-go" signs shall only be used if approved by the Engineer.

A.6 Traffic signals, when used, shall be sited on the nearside of the travelled way in positions which shall be clearly visible to on-coming drivers for a distance consistent with safe stopping. Appropriate advance warning signs shall be provided and maintained in a clean condition.

A.7 The Contractor shall, whenever necessary, provide flagmen at specified locations with the sole task of directing traffic through or around the Site and shall provide and erect within or near the Site any warning or directional signs the Engineer may require.

A.8 All barriers, traffic signs, signals and other such devices shall be erected, maintained and removed when necessary, as directed by the Engineer.

B. One-Way Traffic Operation

B.1 Whenever it becomes necessary to operate one-way traffic along any stretch of road in or around the Site, the Contractor shall, for the purpose of maintaining traffic, provide a detour with a traffic lane of not less than 3.5 m wide and shall keep it open to traffic. If construction work is proceeding at more than one location, the Contractor shall carry out his work so as to cause minimum obstruction and delay to traffic and shall be responsible for control of traffic using such detour lanes.

B.2 At locations where traffic is handled along single lane sections and whenever required by the Engineer, movement of the Contractor's equipment from one part of the Site to another shall be in accordance with the traffic regulations and by agreement with the concerned Authorities. Material spilt as a result of hauling operations along or across the highway shall be removed forthwith by the Contractor, failing which the Engineer shall arrange for its removal by others, at the Contractor's expense.

C. Half Width Construction of Highway

C.1 Where, in the opinion of the Engineer, construction of a detour is inappropriate, new construction shall be limited to half the highway width at a time.

C.2 Details of half width stretches and the timing of construction of each shall be included in the Contractor's Programme for execution of the Works.

C.3 Half width construction shall be kept to the minimum length possible.

6.07.3 DETOUR CONSTRUCTION AND MAINTENENCE

A. The Contractor shall submit to the Engineer for approval, details of the layout, pavement construction, drainage, lighting, signing and marking of any detours, which he proposes. He shall give the Engineer at least 7 day’s notice of such proposals.

B. The standard of construction of each temporary detour shall be adequate in all respects for the class of traffic that will use it. Any utilities located below the detour shall be properly protected. The width of any detour shall be not less than that of the existing highway (including sidewalks), which it replaces unless otherwise provided for. The minimum width shall be 10.5 m.

C. Detours shall be properly drained at all times.

D. The standard of lighting levels and uniformity for each detour shall be at least equivalent to that existing on the highway. In addition to lighting of detours, the Contractor shall provide and maintain illumination of all temporary traffic signs during the hours of darkness.

E. All detours shall be signed, marked and furnished with traffic signals conforming to the requirements of the CDR Safety, Health and Environmental Regulations and LIBNOR "Signalisation et Equipments de la Route", and as shown on the Drawings.

F Any obstruction associated with detours, including ramps, variations of lane widths, siting of warning signs, etc., shall be marked by the use of cones, flashing beacons and warning lamps, appropriate to the location concerned.

G. Detours shall be constructed in advance of the affected works.

H. The Contractor shall monitor and maintain detours, providing 24 hour cover to ensure that all signs, lighting and barriers are in place and functioning and that the road surfaces and rights of way are maintained at all times. He shall liaise with the emergency services in order to provide emergency call out facilities to effect repairs in the event of accidents.

I. Before any detour is opened to traffic, the Contractor shall obtain approval from the Engineer. The diversion of traffic on the day on which the detour is initially put into operation shall be carried out with the assistance and coordination of the Police Department.

6.07.4 REMOVAL OF DETOURS

A. General

A.1 The Contractor shall ensure the free movement of vehicular traffic prior to the removal of any temporary detour road.

A.2 Removal of temporary detours shall be carried out at times determined by the Engineer during construction and at the end of the Contract.

B. Detours Outside of the Right of Way

B.1 Unwanted pavement furnished for temporary detours outside the right of way shall be removed. Unsurfaced areas shall be backfilled and graded to levels to match the surrounding lands.

B.2 Grassed areas disturbed by the works shall be restored to their former condition after removing the temporary detours.

B.3 All facilities furnished for temporary detours, including barricades, barriers, traffic signs, flashing signal lights and unwanted lighting devices, shall be removed at the end of the Contract as directed by the Engineer.

C. Detours Inside the Right of Way

C.1 The Contractor shall arrange for the removal of all unwanted temporary detour items and facilities furnished inside the right of way at times approved by the Engineer and in line with the approved phased construction scheme.

6.07.5 MEASUREMENT

Works required for the construction of detours shown on the Drawings or ordered by the Engineer shall be measured and paid for in accordance with the applicable sections of the Specification and the pay items set for such works in the Bill of Quantities. Works required for the construction and removal of the detour but not listed in the Bill of Quantities shall not be measured for direct payment but shall be considered as subsidiary works the cost of which will be deemed to be included in the Contract prices for pay items.

SECTION 6.08 HIGHWAY SIGNING

6.08.1 SCOPE

A. The work covered in this Section consists of furnishing and installing all road signs complete with footings, bases, posts, and all other parts and appurtenances necessary for installation in accordance with this Specification and Drawings and as directed by the Engineer.

B. This section also covers furnishing and installing permanent regulatory overhead signs mounted on steel structures.

6.08.2 PRODUCTS

A. The Contractor shall submit a written request to the Engineer for approval of all traffic sign materials, giving makes, types and specification details, including samples of complete traffic signs, to be used in the Works.

B. The Contractor shall obtain approval of all sign materials before ordering any traffic signs.

6.08.3 MATERIALS

A. Concrete Bases (for Road Signs)

Sign base dimensions shall be as shown on the Drawings. Concrete shall be in accordance with the requirements of Section 5.01: Concrete, Materials and Testing using a 25 mm maximum aggregate size. The quality shall be that of reinforced concrete.

B. Reinforcement

Reinforcing steel shall conform to the relevant requirements of Section 5.03: Steel Reinforcement.

C. Bolts

Bolts, nuts and washers shall be of stainless steel conforming to ASTM A-276 chroming-nickel grade with a minimum yield strength of 2400 kg/cm^2.

D. Ordinary and Break-Away Posts (for Road Signs)

D1. Posts shall be manufactured from one of the following materials:

- Steel in the form of structural hollow sections or rolled steel joists hot-dip galvanized after fabrication. The weight of the zinc-coating shall be a minimum of 450 g/m^2.
- Aluminium in the form of drawn tubes complying with grades 6063 – TF or 6082 – TF of BS EN 573 or bars or extruded tubes or sections complying with grades 6063 – TF or 6082 – TF of BS 1474:1987

D2 . Posts shall have dimensions and thicknesses as shown and detailed on the Drawings The top of posts shall be closed or capped with a PVC cap.

E. Sign Plates

E1. Sign plates shall be constructed from one or more of the following materials: -

- Sheet aluminium and sheet aluminium alloy of minimum thickness 3.0 mm for flat plate (non bent edge) signs or 2.5 mm for bent- edged stiffened signs
- Extruded aluminium and extruded plank sections complying with grades HE-9TF, HE9-TE or HE 30-TF of BS 1474:1987. Planks shall have a maximum length of 4 m. 15 cm and 20cm wide planks shall have a minimum thickness of 2mm and 25 cm and 30 cm wide planks shall have a minimum thickness of 2.5 cm.

E2. All overhead sign plates and other signs with a face area of over 2 square metres shall be constructed from extruded aluminium in accordance with D2 above.

E3. Sign plates shall be non-porous, smooth, flat, rigid, weatherproof and shall not rust or deteriorate. They shall be cut and smoothed so that there are no sharp edges. The corners shall be rounded off to a minimum radius of 30 mm for road signs and 100 mm for overhead signs. Any trademark or other printing shall be carefully removed with a lacquer thinner.

6.08.4 SIGN SHEETING AND SIGN FACE CONSTRUCTION

A. The sign faces shall be made with wide angle reflective high intensity sheeting which shall be processed onto the plate. The manufacturer's trademark or name and sheeting grade shall be clearly shown as a non-removable built-in mark on the sheeting. Sheeting material shall be accompanied by a certificate of compliance listing its detailed specifications and identifying the standards to which it complies.

B. The base of the sign shall be of white, blue, green or yellow wide angle high intensity reflective sheeting or as described in the foregoing paragraphs. The particular sign message shall be as indicated on the Drawings or instructed by the Engineer.

C. Prior to the application of reflective film, the signs shall be cleaned and wax free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaners, such as medium fine steel wool. They shall be rinsed thoroughly and dried with hot air before applying any reflective material.

D. The sheeting shall be cut by a band saw or power guillotine. The cutting tool shall be clean and sharp. The sheeting shall be cut from face side and held securely during cutting to avoid shattering and edge chipping.

E. The sheeting after application to the sign base shall not come off the edges nor shall it peel off nor warp. The surface shall be smooth, flat and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weatherproof.

F. The sheeting of different reflective colours shall have a life of 10 years after application to the face of the sign.

G. This life of 10 years shall be the outdoor at-site life during which period it shall not fade in colour or its reflectivity, nor shall it deteriorate in any way.

H. The back face of the sign plate shall be treated and painted to the colour specified in the Drawings or by the Engineer so that the life of the two faces remains the same.

6.08.5 LETTERING

A. Sign lettering shall be in clear open letters of the English language, and in "Al-Naskh" script in Arabic language.

B. The Contractor shall comply with lettering scripts and dimensions as described in the LIBNOR Standard "Signalisation et Equipments de la Route" published by the Committee of Lebanese Norms.

6.08.6 LOCATION OF SIGNS

A. Signs shall be located as shown on the Drawings. These locations are subject to field adjustments by the Engineer. No sign shall be erected prior to the Engineer's final approval of the location.

6.08.7 EXISTING SIGNS

A. Where shown on the Drawings or ordered by the Engineer, the existing signs and, if so indicated, the sign structure shall be replaced or removed by the Contractor. Prior to any work, and immediately after the site submission, the Contractor shall prepare within two weeks a detailed inventory of existing erected signs showing their location, type, material, and physical condition. The Engineer shall revise and examine this inventory in order to determine whether existing signs shall be removed, relocated or replaced, either partially or entirely.

6.08.8 SIGN REMOVAL

A. Where shown on the Drawings or ordered by the Engineer, existing signs shall be removed by the Contractor. Where indicated, the Contractor shall remove concrete pedestals to a minimum of 15 cm below finished grade and backfill the hole to the satisfaction of the Engineer. Where the existing sign post is located within a sidewalk area, the Contractor shall remove the post and finish the area so as to make the sidewalk continuous. Signs plates, posts and metal structural members shall remain the property of the owner and shall be stockpiled, as specified by the Engineer, at the location designated by the owner. The Contractor shall dismantle all signs to leave them in a reusable condition.

6.08.9 SIGN REPLACEMENT

A. Where shown on the Drawings or ordered by the Engineer after his revision of the existing sign messages or layouts, the Contractor shall remove and reinstall sections or all of the existing sign or furnish and install new message components. Prior to installing the revised sign, the Contractor shall thoroughly clean the sign face and plug all existing rivet holes with aluminium blind rivets painted the same colour as the sign background. Modifications to the sign shall be completed during the same day in which work is commenced and while the sign is in place. All new materials necessary to accomplish this work shall be the same type and size as the existing components, and it shall be the Contractor’s responsibility to verify such component type and size. Materials damaged by the Contractor shall be replaced at his own expense. Existing materials not reinstalled shall become the property of the owner and shall be removed from the project as directed by the Engineer.

6.08.10 SIGN RELOCATION

Where shown on the Drawings or as directed by the Engineer, the existing signs and the sign structures shall be relocated by the Contractor. Where the existing sign structure is mounted on concrete pedestals, the Contractor shall remove the pedestal to a minimum of 15 cm below finished grade, and backfill the remaining hole with material similar to that surrounding the hole. At the new sign location the Contractor shall provide the necessary materials, labour and hardware to erect and provide an operable unit to the satisfaction of the Engineer. All materials damaged by the Contractor shall be replaced at his own expense.

6.08.11 ERECTION OF SIGNS

A. All signs shall be mounted approximately at right angles to the direction of, and facing, the traffic they are intended to serve.

B. To get maximum effectiveness from reflecting sheeting, the sign shall be properly located and should be faced 3 degrees away from the road.

C. To avoid specular glare, the sign face shall be tilted back two or three degrees.

D. Signs shall be installed at the locations and in accordance with details shown on the drawings and in accordance with the approved samples and materials.

E. All sign components shall withstand a wind load of 150 kg per square metre of sign surface without permanent deformation. Sign plates not exceeding 1 m in width shall be supported on single posts. Sign plates exceeding 1 m in width shall be supported on double posts, with or without bracing.

F. Sign plates shall be attached to the posts with stiffeners, bolts, and screws which shall be painted in the same colour as the corresponding area of the sign plate.

G. For single post- mounted signs a locking pin shall be incorporated into the sign plate attachment system to prevent rotation of the sign plate around the axis of the post.

H. The exact location of the sign shall be designated by the Engineer.

I. Holes for posts shall be provided to a depth permitting the installation of the post and the base to the depth indicated on the Drawings or required by the Engineer. All loose material shall be removed from excavation and bearing surface of footings and the excavation shall be cleaned and cut to an even surface prior to the placement of concrete base. Approved backfill material shall be used. The adjacent surface shall be neatly graded and compacted.

6.08.12 GUARANTEE BY CONTRACTOR

A. All signs shall be guaranteed by the Contractor against any defect in material and workmanship for a period of 1 year from the date of completion of the Works under the Contract. If any defect should arise due to material or workmanship, it shall be rectified by the Contractor at his own expense.

B. If such a defect is rectified by other than the Contractor in accordance with the Employer’s instructions, the expense of such rectification shall be deducted from any monies due to the Contractor under the Contract.

C. Reflectivity of the signs shall be tested prior to the issue of the Certificate of Completion and again prior to the Issue of the Defects Liability Certificate. They shall also be assessed at any other time during the Defects Liability Period to ensure conformance with the manufacturers' specifications. The Contractor shall provide assistance in terms of traffic management provision and support labour, testing equipment and materials for the duration of testing when requested by the Engineer.

6.08.13 MEASUREMENT

A. Small signs (triangular, circular and rectangular signs up to 1 square metre in surface plate area) shall be measured by the number of such signs furnished and installed (excluding sign post supports) and accepted.

B. Rectangular and Trapezoidal Signs over 1 square metre in surface plate area and intended for ground mounting, shall be measured by the square metre of surface area furnished, installed (excluding sign post supports) and accepted. Each sign area shall be measured to the nearest 0.01 square metre.

C. Rectangular signs intended for mounting on overhead support structures, shall be measured by the square metre of surface area furnished, installed (including sign stiffening but excluding sign support brackets) and accepted. Each sign area shall be measured to the nearest 0.01 square metre.

D. Multiple Post Sign Support Assemblies and Breakaway Multiple Post Sign Support Assemblies shall be measured by the number of each type of such assemblies furnished, installed and accepted.

E. Overhead Sign Support Structures (sign gantries and cantilever) shall be measured by the number of each type and size of such structures furnished, installed (including sign support brackets but excluding sign panels and stiffening) and accepted.

F. Removal and stockpiling of existing signs shall be measured by the number of signs and supports dismantled and transported to a location specified in the Contract or instructed by the Engineer. The rate shall include covering or disposal off site of the post foundations and reinstatement of the post foundation excavation all as specified in the Drawings or instructed by the Engineer.

G. Relocation of existing signs shall be measured by the number of signs and supports re-erected at the location specified in the Contract or instructed by the Engineer. The rate shall include dismantling the sign from its original location, transportation and temporary storage, covering or disposal off site of the existing post foundations and reinstatement of the post foundation excavation as specified in the Drawings or by the Engineer, repairs to and rehabilitation of the existing sign plate, posts and mountings, replacement of defective components, the volume of concrete specified in bases installed and accepted and all equipment, labour, tools and incidentals necessary to complete the item.

H. Illumination of signs shall be measured separately as prescribed in Section 7.09: Sign Illumination.

I. Excavation, backfilling, concrete, reinforcement and other ancillary items shall not be measured for direct payment, but shall be considered as subsidiary work, the costs of which will be deemed to be included in the Contract prices for the Pay Items.

SECTION 6.09 ROADWAY MARKINGS

6.09.1 SCOPE

A. The work covered in this Section consists of the furnishing and application of traffic markings to highway pavements for the guidance, control and safety of vehicular and pedestrian traffic.

B. White and yellow painted markings shall include centrelines, lane lines, border (edge) lines, pedestrian crossing lines, stop lines, chevron striping (at gore areas), directional arrows, lettering, and symbols using the following materials as appropriate and as shown on the Drawings.

- Thermoplastic Reflectorized Paint (TRP)
- Reflectorized Cold Paint (RCP)
- Preformed Reflectorized Thermoplastic Film

C. Cold paint applications shall be used for the following, or as indicated on the Drawings:

- For all markings on roads with slow moving traffic (design speed less than 30 kph).
- For markings on existing road pavements over one year old
- On roads in areas over 1200 metres above sea level, that are regularly snow-ploughed in winter.
- For temporary road markings
- For yellow painted curbs adjacent to the pavement edge where parking is prohibited.
- On bituminous speed bumps

D. Preformed, reflectorized, thermoplastic film shall be used where appropriate and as shown on the Drawings or as instructed by the Engineer.

6.09.2 MATERIALS

6.09.2.1 Thermoplastic Reflectorized Paint (TRP)

A. TRP shall consist of a homogenous mixture of thermoplastic binder, white or yellow pigment, glass reflectorizing spheres and filler that is to be applied to the pavement in a molten state by mechanical means. Upon cooling to normal pavement temperature, this material shall produce an adherent, reflectorized paint line of specified thickness capable of resisting deformation.

B. White and yellow TRP shall conform to AASHTO M-249, except where stated otherwise in paragraphs C to D below.

C. For thin lines (1.2 mm thick or less) the minimum TiO_2 content of the mix shall be 10%. For other lines and markings with thicknesses over 1.2mm the minimum TiO_2 content shall be 6%. In either case, daylight luminescence immediately after application shall be 75% minimum.

D. Pre-mixed glass spheres shall occupy a minimum of 30% by weight of the TRP for thin lines (1.2 mm thick or less) and 20% for thick lines. In any case night time retroreflectivity shall be at one year of age not less than 150 mcd/ lux sq. m. mixture and shall conform with the following requirements: -

D1. Crushing Resistance: An 18 kg dead weight for No. 20 to No. 30 mesh spheres shall be the average resistance when tested in accordance with ASTM D-1213.

D2. Roundness: A minimum of 75% shall be true spheres when tested in accordance with ASTM D-1155. Not less than 70% of the spheres of each sieve size shall be free from imperfections of all types, including film, scratches, pits, clusters, and opaqueness.

D3 . Index of Refraction: The spheres mixed into the material shall have a minimum index of refraction of 1.65 when tested by the liquid immersion method at 25 degrees C, and the spheres automatically applied to the surface of the TRP line shall have a minimum index of refraction of 1.5.

D4. Gradation: When tested in accordance with ASTM D-1214, the spheres used in the TRP shall have the following gradation:

Standard Sieve Size	**% Passing by Weight**
1.70 mm (No. 12)	100
0.180 mm (No. 80)	0 – 5

D5. Chemical Resistance: The glass spheres shall withstand immersion in water and acids without noticeable corrosion or etching, and shall not be darkened or otherwise decomposed by sulphides. A 3 to 5 gm sample shall be placed in each of 3 glass beakers or porcelain dishes, one covered with distilled water, the second with a 3 N solution of sulphuric acid and the third with a solution of 50% sodium sulphide, 48% distilled water and 2% aerosol 1B or similar wetting agent. No darkening, hazing, or other evidence of instability shall be noticeable in the glass spheres when examined microscopically, after one hour immersion.

D6. Silica Content: The silica content (SiO2) of the spheres shall be 60% plus or minus 5% when tested in accordance with Federal Test Method 141a.

6.09.2.2 Cold Paint

A. Traffic Paint shall consist of a ready mixture of binder, white or yellow pigment, and filler specifically compounded for cold application and adhesion to finished

paved areas. Paint shall be reflectorized by adding reflective spheres before the film dries or sets, using drop-on or pressurized methods.

B. Reflectorized white and yellow cold applied traffic paint shall conform to AASHTO M-248, Type F. The surface application of glass spheres shall conform to AASHTO M 247, Type I.

6.09.2.3 Preformed Thermoplastic Reflectorized Film

A. Preformed thermoplastic reflectorized film shall be homogenous, extruded prefabricated white or yellow, of the specified shape and capable of being affixed to bituminous or cement concrete surfaces. It shall contain reflective glass spheres uniformly distributed and bonded to the top surface of the material. The film shall be weather resistant and shall not show any appreciable fading, lifting, shrinkage, significant tearing, roll back or other signs of poor adhesion throughout its design life.

B. The thermoplastic film without adhesive shall be a minimum of 1.5 mm thick.

C. The film as supplied shall be of good appearance, free from cracks and discolorations and the edges shall be clean cut and well defined. It may be supplied complete with a precoated factory-applied, pressure sensitive adhesive backing with a protective release paper or with separate adhesives as recommended by the manufacturer.

D. The adhesive shall allow the plastic film to be repositioned on the pavement surface to which it is to be applied before permanently fixing it in its final position.

E. The preformed thermoplastic film shall consist of the following: -

	Minimum % by Weight
Polymeric resins and plasticizers	20
Pigments	30
Reflective glass spheres	20

F. The pigments shall be selected and blended to provide a white or yellow marking film which conforms to standard highway colours throughout the design life of the film.

G. The plastic film shall be sufficiently flexible so that a temperature of 26 – 28^{o}C an unmounted piece of material (without adhesive and paper backing) 75 mm by 150 mm, may be bent over a 25mm mandrel until the end faces are parallel and 25 mm apart without showing any fracture lines in the uppermost surface.

H. The plastic film (without adhesive and paper backing) shall have a minimum tensile strength of 0.6 kg/ sq. cm when a specimen 150 mm by 25mm is tested in accordance with the requirements of ASTM D 638. The rate of pull of the test shall be 6 mm/ minute. The test shall be conducted at a temperature of 21 – 27^{o}C. The elongation shall be no greater than 75%.

I. A 150 mm long by 25 mm wide section of the plastic film (without adhesive and paper backing) shall support a dead weight load of 1.8 kg for not less than 5 minutes at a temperature of 21 – 27^{o}C.

J. The plastic film shall have a maximum loss in weight of 0.25 grammes in 500 revolutions when abraded according to Federal Test Method Standard No. 141, Method 6192, using H-18 calibrated wheels with a 1,000 gram load on each wheel.

6.09.3 APPLICATION AND INSTALLATION

A. Equipment for Marking

A1. The equipment used for pavement marking shall consist of truck-mounted units, motorized equipment or manually operated equipment, depending on the type of markings required. The truck-mounted or motorized unit for centrelines, lane lines, and edge lines shall consist of a mobile, self-contained unit carrying its own material and capable of operating at a maximum speed of 10 km/h while applying paint. The hand application equipment shall be sufficiently manoeuvrable to install centrelines, lane lines, edge lines, gore striping, turn lines, crosswalks, stop lines, kerb lines, arrows and legends.

A2. Spraying equipment shall be capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly on the pavement. Each paint tank shall be equipped with cut-off valves which will enable broken (skip) lines to be sprayed automatically. Each nozzle shall have a mechanical bead dispenser that will operate simultaneously with the spray nozzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle shall also be equipped with suitable line guides and shall provide a method for cleaning the surface of dust just prior to paint application.

A3. The spray machine for application of reflectorized paint lines and other markings shall have an attachment to accurately regulate the rate of application and a tachometer or other approved device to ensure uniform paint application at the designated rate. It shall be adjustable to ensure the painting of one or two adjacent lines simultaneously along the centreline. The paint shall be properly agitated while in operation.

A4 . Equipment for application of thermoplastic reflectorized paint lines and other markings shall deposit the plastic material in a hot molten state on the pavement, italicising either an extrusion or spray method. Equipment shall be capable of providing continuous mixing and agitation of the material which will be maintained at the correct application temperature. The use of direct flame heat shall not be permitted.

A5. An automatic glass sphere dispenser with a synchronized automatic cut-off shall be attached to the applicator machine. The dispenser shall utilize pressure type spray guns which will embed the spheres into the surface to at least 0.5 times the sphere diameter. The dispenser shall also be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

A6. Hand equipment shall be used only for painted markings, including arrows, pedestrian crossings, stop lines symbols, legends, kerb lines and short sections of linear markings where the use of motorised equipment is not practical. The hand equipment shall be capable of holding a minimum of 25 kg and not more than 100 kg of molten material unless otherwise agreed with the Engineer.

A7. Pre-melting equipment shall provide for continuous mixing and indirect oil jacket heating of the material. Heating by direct flame shall not be permitted. The heating equipment shall be of such capacity to maintain the thermoplastic at the required temperatures as specified by the supplier. It shall be thermostatically controlled and fitted with safety devices ensuring combustion cut-off in case of defects.

A8. Equipment for the application of thermoplastic shall have a material tank to the specification in A7 above. Spray application equipment shall have a pressurised tank and shall be fitted with a low pressure spray system. All spray lines and appurtenances leading from the heated pressure tank to the spray nozzle shall be fully insulated or suitably heated to allow the heated material to leave the spray gun at a minimum temperature of 225ºC. Spray equipment shall have a low pressure spray system and screed equipment shall allow continuous control of line thickness regardless of speed. All spray lines and appurtenances leading from the heated pressure tank to the spray nozzle shall be fully insulated and/ or suitably heated to allow the heated material to leave the spray gun at the required temperature. Screed and spray line laying equipment shall be designed to simultaneously apply reflective glass beads in synchronisation with the thermoplastic material.

A.9 Preformed reflectorized thermoplastic film for traffic markings shall be applied by manual or machine methods consistent with the type of markings and with the approval of the Engineer.

B. Setting Out and Pavement Preparation

B1. The Contractor shall set out all control points necessary for locating paint lines and markings. On irregular widths of highway, the locations of border (edge) lines shall be adjusted to provide a smooth alignment on the pavement surface. The locations of all painted markings and each location for raised pavement markers and studs shall be accurately established and shall be subject to approval by the Engineer before application and installation commence. Markers and studs shall not be located over longitudinal or transverse pavement joints.

B2 . The area of highway surface on which markings are to be applied shall be free of dirt, existing paint lines if directed, curing compound, grease, oil, moisture, loose or unsound layers, and any other material which could adversely affect the bond. The area shall be thoroughly cleaned (by sweeping and air blasting as necessary) to the satisfaction of the Engineer before proceeding with painting.

B3. Pavement marking shall not proceed when there is moisture on the pavement surface or the air is misty, or the surface temperature of the pavement is below 10°C; or when wind or other conditions may cause a film of dust to be deposited on the surface, or in other conditions that, in the opinion of the Engineer, could displace, damage, or adversely affect the bonding of the material to the pavement surface. Any markings damaged due to water or rain or suffering from lack of adhesion through any cause shall be removed and replaced at the Contractor's expense.

C. Thermoplastic Reflectorized Paint (TRP) Application

C1. To ensure optimum adhesion, the thermoplastic paint shall be applied in a molten state within the temperature range recommended by the manufacturer.

C2 Thermoplastic painted markings may be applied by screed or spray to the following minimum thicknesses or as specified on the Drawings. Unless stated on the Drawings or elsewhere in the Contract Documents, the Engineer shall confirm the bi-directional daily traffic figures.

Method of Application	**Bi- Directional Daily Traffic (PCU per Day)**		
	<20000	**20000-60000**	**60000>**
Screed	2mm	2.5mm	3mm
Spray*	2mm	2.5mm	3mm

* In two or more applications

C3. The completed lines shall have a continuous and uniform cross-section, and shall have clean, sharp edges. The width of paint line specified shall be applied in one application.

C4. Reflective beads shall be applied before the thermoplastic material has set by the automatic glass sphere dispenser attached to the painting machine. The sphere dispenser shall embed at least 65% the sphere diameter into the surface. The application rate of spheres shall be a minimum of 0.3 kg/sq. m.

D. Cold Paint Application

D1. Cold paint shall be applied in 2 passes with a minimum of six weeks between each pass.

D2. A glass sphere top dressing shall be applied to the both paint applications immediately after it has been placed by the automatic glass sphere dispenser attached to the painting machine. The sphere dispenser shall embed at least 65% of the sphere diameter into the surface. The application rate of spheres shall be a minimum of 0.3 kg/sq. m.

D3. The markings shall be protected for a minimum of 20 minutes (or longer if necessary according to the manufacturer's recommendations) to allow for drying and curing of the paint.

E. Kerb Paint Application

E1. The paint shall be sprayed to cover entirely the kerbstone between the pavement edge and tile edge (25 to 35 cm width depending on the existing condition of the kerb). Areas adjacent to those to be painted shall be protected and covered during paint application. The surface of the kerbstone shall be free of dirt, grease, oil, moisture loose or unsound layers and any other material which could adversely affect the bond or the colour. The area shall be thoroughly cleaned to the satisfaction of the Engineer before proceeding with painting.

F. Protection of Markings

F1. Immediately following the application of paint lines and other markings on pavements open to traffic, traffic cones or other approved devices shall be placed alongside or over the paint at intervals not exceeding 10 metres and shall remain in place until the paint has dried.

F2. Traffic shall be prevented from crossing wet paint lines and the Contractor shall use sufficient numbers of flagmen, barricades, or other protection, particularly at crossings, to prevent traffic from crossing wet paint. Sections of paint which have been damaged by traffic before the paint has cured, shall be repaired and the pavement outside the painted area cleaned at the Contractor's expense.

F3. Temporary barricades and signs as specified, or required by the Engineer, shall be erected at the beginning and end of the highway section on which the Contractor proposes to apply paint markings or install markers or studs. On completion, the temporary barricades and cones shall be moved ahead to the next section. Barricades and cones shall not be left in place overnight. The equipment shall be operated that it will be unnecessary for public traffic to cross the newly placed material behind the equipment in order to safely pass the equipment.

F4. Protective and traffic warning devices shall be approved by the Engineer before any placement.

G. Tolerances and Finish

G1. A tolerance of 12 mm over or 3 mm under the specified line width shall be allowed, provided the variation is gradual and does not detract from the general finished appearance of the line. Segments of broken line may vary up to 30 mm from the specified length. Segments shall be square at each end without mist or distortion. Deviations from the control line of up to 25 mm on tangents and 50 mm on curves shall be accepted, provided the deviation does not increase or decrease at a rate of more than 15 mm in 10 m. Lines that do not meet these tolerances shall be removed and replaced at the Contractor's expense.

G2. When it is necessary to remove paint, this shall be carried out using a method satisfactory to the Engineer and shall not damage the underlying pavement surface. When it is necessary to correct a deviation which exceeds the permissible tolerance in alignment, the affected length of line shall be removed plus an additional 5 metres in each direction, and a new line painted.

G3. All pavement markings shall maintain a minimum retro-reflectivity of 100 millicandellas up to the end of the defects liability period following completion of the final application of paint.

6.09.4 SAMPLING AND TESTING

A. All material shall be shipped to the job site in undamaged, sealed original packaging, clearly identifying each material by name, colour, manufacturer, batch number and date of manufacture. All material shall be accompanied by certified test results verifying compliance with all specified physical and chemical requirements conforming to latest versions of AASHTO M-247, M-248 and M-249. The Contractor shall be fully responsible for providing all materials conforming to the required specifications.

B. All paint products and other materials designated by the Engineer shall be available for testing. Sampling shall be performed by the Contractor in the presence of the Engineer. Materials shall be sampled in their original containers and the containers resealed as approved by the Engineer. All samples shall be packaged for shipment as approved by the Engineer. Samples shall be transported to an independent laboratory as directed and approved by the Engineer. Paint materials shall not be used until approved by the Engineer.

C. If instructed by the Engineer, the Contractor shall install, at his own expense, at a designated test site, strips of samples of materials proposed for all types of pavement markings for verification and testing for compliance with the Specifications.

D. The following road stripe and marking characteristics shall be tested prior to the issue of the Certificate of Completion and again prior to the Issue of the Defects Liability Certificate. They may also be assessed at any other time during the period from the application of test markings to the end of the defects liability period:

- Reflection in daylight or under road lighting
- Retroreflection under vehicle headlamp illumination
- Colour (luminance and/or chromaticity)
- Skid resistance

E. The Contractor shall provide assistance in terms of traffic management provision and support labour, testing equipment and materials for the duration of testing as and when requested by the Engineer.

6.09.5 GUARANTEE BY CONTRACTOR

A. All marking and painting shall be guaranteed by the Contractor against any defect in material, workmanship, performance during the whole defect liability period. If any defect should arise due to material or workmanship, it shall be rectified by the Contractor at his own expense.

B. If such a defect is rectified by other than the Contractor the expense of such rectification shall be deducted from any monies due on this Contract.

C. The Contractor shall furnish copies of manufacturers' warranties and guarantees.

6.09.6 TYPES OF PAVEMENT MARKINGS

A. Continuous White Line (Type MR1)
A continuous longitudinal white line 20 cm wide

B. Continuous White Line (Type MR1-A)
A continuous longitudinal white line 15 cm wide.

C. Emergency Stop Lane Line (Type MR1´)
A broken longitudinal white line 20cm wide. The broken or "skip" pattern shall be based on 48.0 m unit consisting of 36 m line and 12 m gap.

D. Continuous Yellow Line (Type MR2 and MR2-A)
A continuous longitudinal yellow line, 20 cm wide.

E. Continuous Double Yellow Line (Type MR2-2)
Two continuous longitudinal yellow lines, each 20 cm wide, separated by a 10 cm space.

F. Broken White Line (Type MR3)
A broken longitudinal white line, 15 cm wide. The broken or "skip" pattern shall be based on 6 m unit consisting of 4m line and 2 m gap.

G. Broken White Line (Type MR3')
A broken longitudinal white line, 25 cm wide. The broken or "skip" pattern shall be based on a 5.33 m unit consisting of 4m line and 1.33 m gap.

H. Broken White Line (Type MR3A)
As Mr3 but with a width of 12 cm.

I. Broken White Line (Type MR3'-A)
As Mr3 but with a width of 20 cm.

J. Double Broken White Line (Type MR3A – 3A)
Two broken longitudinal yellow lines, each 12 cm wide and 10 cm apart. The broken or "skip" pattern shall be based on 6 m unit consisting of 4m line and 2 m gap.

K Broken White Line (Type MR3'- B)
A broken longitudinal white line, 20 cm wide. The broken or "skip" pattern shall be based on a 4 m unit consisting of 3 m line and 1 m gap.

L. Broken White Line (Type MR4)
A broken longitudinal white line, 15 cm wide. The broken or "skip" pattern shall be based on a 16 m unit consisting of 4m line and 12 m gap.

M. Broken White Line (Type MR5)
A broken longitudinal white line, 12 cm wide. The broken or "skip" pattern shall be based on a 12 m unit consisting of 3 m line and 9 m gap.

N. Broken White Line (Type MR5-A)
A broken longitudinal white line, 20 cm wide. The broken or "skip" pattern shall be based on a 6 m unit consisting of a 1.5m line and 4.5 m gap.

O. Broken White Line (Type MR5 - 5)
Two broken longitudinal yellow lines, each 12 cm wide. The broken or "skip" pattern shall be based on a 12 m unit consisting of 3 m line and 9 m gap.

P. Broken White Line (Type MR6)
A broken white line, 20 cm wide. The broken or "skip" pattern shall be based on a 6 m unit consisting of 3 m line and 3 m gap.

Q. Broken White Line (Type MR6 - A)
A broken longitudinal white line, 25 cm wide. The broken or "skip" pattern shall be based on an 8 m unit consisting of 4 m line and 4 m gap.

R. White "Stop" Line (Type MR7)
A transverse solid white line, 50 cm wide.

S. Broken White "Give Way" Line (Type MR8)
A transverse broken white line, 40 cm wide. The broken or "skip" pattern shall be based on a 1 m unit, consisting of a 0.5 m line and a 0.5 m gap.

T. Broken White Line (Type MR9)
A transverse broken white line, 15 cm wide used transversely to delineate the stopping point at traffic signals. The broken or "skip" pattern shall be based on a 1 m unit, consisting of a 0.5 m line and a 0.5 m gap.

U. Broken White Line (Type MR9 -A)
A transverse broken white line, 10 cm wide used at junctions, crossroads and roundabouts. The broken or "skip" pattern shall be based on a 1 m unit, consisting of a 0.5 m line and a 0.5 m gap.

V. Continuous White Line (Type MR10)
A continuous longitudinal white line 12 cm wide.

W. Continuous Double Yellow Line (Type MR10 -10)
Two continuous yellow lines, each 12 cm wide, separated by a 10 cm space.

X. Continuous Mixed Yellow Line (Type MR10 – 3A)
Two longitudinal yellow lines, both 12 cm wide, one continuous and the other based on a 4.5 m unit , consisting of a 3 m line and a 1.5 m gap.

Y. Continuous Yellow Line (Type MR11)
A continuous longitudinal yellow line 12 cm wide. SOLID WHITE line, 40 cm wide unless noted otherwise in the Drawings.

Z. Continuous White Line (Type MR12)
A continuous longitudinal white line 25 cm wide.

AA. Traffic Arrow
A white marking conforming to details shown on the Drawings.

BB. Pedestrian Crossing
50 cm x 300 or 400 cm white lines, with 50 cm gaps between them, as shown on the drawings.

CC. Gore Stripes {Chevrons}
A solid white line, 50 cm wide, used to delineate turn lanes from through lanes, for traffic islands, and for hash marks, and shall be as shown on the Drawings.

6.09.7 MEASUREMENT

Painted Pavement Lines and Painted and Preformed Film Markings shall be measured by the square metre of painted area furnished for each application, applied, cured and accepted.

Painted Kerbstones shall be measured by the linear metre of kerb painted, cured and accepted.

SECTION 6.11 SPEED BUMPS AND RUMBLE STRIPS

6.11.1 SCOPE

Thee work covered in this section includes furnishing materials for and The construction of speed bumps, concrete rumble strips, ceramic marker rumble strips and scored shoulder rumble strips at the locations shown on the Drawings.

6.11.2 MATERIALS

A. Tack Coat

Liquid asphalt for tack coat shall be rapid curing type cutback grades RC-250 or RC-3000 as directed, and shall conform to the relevant requirements of Section 4.02: Bituminous Prime and Tack Coats.

B. Bituminous Mix

The bituminous mix for speed bumps shall conform to the relevant requirements of Section 4.03: Bituminous Binder and Wearing Courses for a wearing course mix unless otherwise shown on the Drawings.

C. Concrete

Unless otherwise shown on the Drawings, Portland cement concrete, for concrete rumble strips shall be Class 210/20 and shall conform to the relevant requirements of Section 5.01: Concrete Mixes and Testing.

D. Reinforcement

Steel mesh for concrete rumble strips shall be of the sizes shown on the Drawings and shall conform to the relevant requirements of Section 5.03: Steel Reinforcement.

E. Ceramic Raised Pavement Markers

Ceramic raised pavement markers for rumble strips shall be of the size shown on the Drawings. Ceramic markers and the epoxy adhesives shall conform to the relevant requirements of Section 6.10: Raised Pavement Markers.

F. Reflective Paint

White reflectorized paint (RP) used to distinguish the speed bumps shall conform to the relevant requirements of Section 6.09: Roadway Markings.

6.11.3 CONSTRUCTION AND INSTALLATION

A. Speed Bumps

A.1 Prior to the application of the tack coat, the bituminous surface shall be cleaned free of all dirt, dust and other foreign substances which, in the opinion of the Engineer, would prevent proper bonding of the tack coat.

A.2 Immediately after the surface has been cleaned and approved by the Engineer the tack coat shall be applied by pressure distributor, or by hand-spraying

equipment which shall achieve a uniform mist type coverage without blotches or streaks. The rate of application shall be between 0.2 and 0.3 litres per square metre unless otherwise required by the Engineer.

A.3 When the tack coat has set and has been approved by the Engineer, the Contractor shall place the speed bump form in position. The hot bituminous mix shall be placed in the forms and consolidated by hand flush with the top of the form.

A.4 After the bituminous mix has been placed in the form and consolidated, the form shall be carefully lifted and removed and rolling operations shall commence. Rolling shall be performed with a suitable type of pneumatic roller initially travelling parallel to the roadway centreline and finally at right angles to the centreline until the speed bump is compacted to the required cross section. The height of speed bumps above the pavement surface shall not exceed 100mm.

A.5 The finished surface of the speed bump shall be painted with white reflectorized paint in accordance with the relevant requirements of Section 6.09 - Roadway Markings.

B. Concrete Rumble Strips

B.1 Concrete rumble strips shall be installed after completion of the bituminous wearing course. Locations shall be marked as shown on the Drawings or as ordered by the Engineer. Saw cutting shall be performed to a minimum depth of 200 mm. Underlying subgrade or base material shall be compacted to 100% AASHTO TI80 maximum density and moistened immediately prior to placing of concrete.

B.2 Concrete shall be placed, vibrated and screeded in accordance with the relevant requirements of Section 5.05: Concrete Pavement. Machine placing and finishing is not required. The installation shall be checked with a full width straightedge before texturing.

B.3 Immediately after initial texturing, the rumble texture shall be achieved using a template which shall produce the size, shape and pattern of scalloped depressions shown on the Drawings. Depression moulds shall be vibrated or forced into the surface of the fresh concrete. The template shall form uniform depressions 20 mm to 30 mm deep, and 75 mm between peaks.

B.4 Moulds shall be withdrawn on completion without damaging the edges of the depression. The Contractor shall periodically check the top surface of the concrete with a straightedge and ensure the template is not displacing the concrete.

B.5 Concrete edges shall be properly finished and the concrete shall be cured in accordance with the relevant requirements of Section 5.02: Concrete Handling, Placing and Curing. If a curing compound is approved for use, additional care shall be taken to ensure that all vertical surfaces of depressions are adequately coated.

C. Ceramic Marker Rumble Strips

Raised ceramic pavement markers for rumble strips shall be installed in the appropriate geometric patterns as shown on the Drawings and in accordance with the relevant requirements of Section 6.10: Raised Pavement Markers.

D. Scored Shoulder Rumble Strips

D.1 Scored shoulder rumble strips shall consist of a series of depressions as shown on the Drawings, extending transversely across the paved shoulder, except for a 300 mm strip adjacent to the travelled way and a 300 mm strip at the outside edge. Each depression shall be the shape of a semi-circular cylinder of 25 mm diameter. Depressions shall be 10 mm to 15 mm deep and spaced 0.2 m or 0.25 m apart longitudinally.

D.2 Scored shoulder rumble strips shall be installed to the required dimensions using a specially constructed steel wheel roller with ridges added to the roller drive drum of the length, spacing, and cross section appropriate to the required scoring.

D.3 Rolling of the depressions shall be performed in lieu of, or immediately following, breakdown rolling of the bituminous shoulder material. The Contractor shall select the weight and sequence of rollers to achieve the required depressions and the required density of the finished pavement.

D.4 The required minimum density of the bituminous course used for the shoulders shall be compatible with the construction of the scored shoulder rumble strips.

6.11.4 MEASUREMENT

A. Bituminous Speed Bumps, Concrete Rumble Strips, and Scored Shoulder Rumble Strips shall be measured by the square metre of each type constructed, completed, and accepted.

B. Ceramic Marker Rumble Strips shall be measured by the number of ceramic raised pavement markers; furnished, installed, completed, and accepted.

C. Unless shown as Pay Items in the Bills of Quantities, all other Works prescribed in this Section shall not be measured for direct payment, but shall be considered as subsidiary works the costs of which will be deemed to be included in the Contract prices for Pay Items.

SECTION 6.13: STEEL GUARDRAILS AND CONCRETE SAFETY BARRIERS

6.13.1 SCOPE

The work covered in this Section consists of the furnishing, construction and erection of steel guardrails, concrete barriers, impact attenuators and glare screens as and where shown on the Drawings.

6.13.2 MATERIALS

A. Metal Beam Guardrail

A.1 The Contractor shall construct all guard rails complete with posts as shown on the Drawings, in accordance with these specifications and in conformity with the lines and grades as directed by the Engineer. The Contractor shall submit to the Engineer for his review and approval shop drawings complete with all details of the type of corrugated steel beams and rails he proposes to use on this project.

A.2 Rail elements and backup plates for W-Beam rail shall conform to AASHTO M180, Class A type 2 galvanized. Rail elements for triple corrugated beam rails used in **Guard Rail Energy Absorbing Terminal** (**G.R.E.A.T**.) proprietary impact attenuators shall conform to AASHTO M180, Class B, Type 2 galvanized. Rail element joints shall be fabricated to lap by not less than 300 mm and be bolted.

A.3 Galvanized beam elements and end sections shall be marked at the point of fabrication with the manufacturer's name or trademark, gauge or thickness and with the coating date or coating lot reference. Each reference shall be readily identified. The identification markings shall be placed where they will not be obscured by posts or laps after erection. No markings, except die stamping approved by the Engineer, shall be placed on the traffic face of the beam. Marking materials used shall resist obliteration during handling.

A.4 All galvanized materials for guardrail shall be carefully handled to avoid damage to surfaces. Any galvanized material on which the smelter coating has been bruised or broken shall be rejected or repaired by a method approved by the Engineer.

A.5 The Contractor shall furnish the Engineer with the manufacturer's certification (Certificates of Guarantee) in triplicate, which states that the materials supplied conform to the requirements of these Specifications. The certification shall include, or have attached, specific results of laboratory tests for specified physical and chemical properties as determined from representative samples of the material which verify conformance to the specifications. The Engineer shall check at random weights and characteristics of guard rail elements for correct conformance. This testing shall be at the expense of the Contractor.

A.6 Rail metal shall withstand a cold bend without cracking of 180 degrees around a mandrel of a diameter equal to 2.5 times the thickness of the sheet metal plate.
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A.7 Rail elements to be erected on a radius of 45 m or less shall be shaped in the shop. The radius of curvature shall be stencilled on the back of each section of rail.

A.8 Rail elements shall be designed to be spliced at intervals not exceeding 4 metres and such splices shall be made at posts, unless otherwise shown on the Drawings.

B. Box Beam Guardrail

B.1 Box beam guardrails shall be hot-formed welded and seamless carbon steel structural tube or cold-formed welded. Posts, splice tongues and plates shall conform to ASTM A 36. Rails shall conform to ASTM A 500, Grade A or B, or ASTM A 501.

B.2 Mill transverse welds shall not be permitted on rail sections. Longitudinal welds shall be made by the resistance, gas shielded arc, submerged arc or plasma arc welding processes and shall be sound, free from defects and shall not be repaired. The welded joint in cold and hot-formed welded rails shall have a minimum tensile strength specified for the railing when subjected to the tensile strap test specified in ASTM E8M (metric).

B.3 Rail sections for tangent runs shall be not less than 6 metres in length. Rail splices shall be a minimum of 400 mm from the centreline of any post.

C. Wire Rope

C.1 Wire rope for cable guardrail, cable guardrail anchor terminals and metal beam guardrail anchor terminals shall conform to AASHTO M 30, Type II, Class A. Equivalent galvanized wire rope with a minimum breaking strength of 19,400 kg shall be acceptable, if approved by the Engineer.

C.2 Wire rope restraining cable for G.R.E.A.T. Hi-Dro and Hi-Dri impact attenuators shall be minimum 22 mm nominal diameter galvanized wire rope conforming to ASTM A 603, Class A.

C.3 Pull-out and secondary cable for Hi-Dro and Hi-Dri impact attenuators shall be minimum 9.5 mm nominal diameter galvanized wire rope conforming to ASTM A 603, Class A.

D. Pedestrian Guardrail

Pedestrian Guardrail shall be welded structural hot dipped galvanized steel complying with the requirements of AASHTO M 232 (ASTM A 153) zinc coating (hot dip) on iron and steel hardware.

E. Posts and Miscellaneous Hardware

E.1 Unless otherwise shown on the Drawings, all steel posts, plates, angles, channels, brackets and anchor assembly units shall conform to ASTM A 36. Cold rolled post sections shall conform to ASTM A 446, Grade B.

E.2 The swaged fittings for anchor terminals shall be machined from hot-rolled carbon steel conforming to ASTM A 576, Grade 1035 and shall be annealed using a method suitable for cold swaging. A lock pinhole shall be drilled through the swage fitting head to accommodate a 7 mm, plated, spring steel pin to retain the stud in the correct position. The stud shall be steel conforming to ASTM A 449. Prior to galvanizing, a 10 mm slot for the locking pin shall be milled into the stud end. The swaged fitting, stud and nut shall develop the full breaking strength of the wire cable.

E.3 Anchor rod eyes shall be hot forged or formed with full penetration welds. After fabrication, anchor rods with eyes that have been formed with any part of the eye below 870 ^{o}C during the forming operation or with eyes that have been closed by welding shall be thermally stress relieved prior to galvanizing. The completed anchor rod, after galvanizing, shall develop a strength of 23,000 kilograms.

E.4 Clevises shall be drop forged galvanized steel and shall develop the full specified breaking strength of the wire cable.

E.5 The concrete insert assembly for Type 4 anchor terminals (beams of corrosion resistant steel - AASHTO M180) shall be fabricated as shown on the Drawings. Ferrules shall be steel conforming to ASTM A 108, Grade 12 L 14. Inserts shall be tapped to the dimensional requirements specified in ASTM A 563 for nuts receiving galvanized bolts. Insert assembly wires shall conform to ASTM A 510, Grade 1030, and have a minimum tensile strength of 686 MN/m^2 (7,000 kg/cm^2). Welded attachments of wires to ferrules shall develop the full tensile strength of the wire.

E.6 Turnbuckles shall be steel of commercial quality and shall have a minimum breaking strength of 1,500 kilograms. Turnbuckles shall be galvanized in accordance with ASTM A 153. Compensating and non-compensating cable ends shall be cast steel conforming to ASTM A 27 or malleable iron conforming to the requirements of ASTM A 47M (metric). Compensating devices shall have spring constants of 8,000 kg/m plus or minus 500 kg/m and permit a travel of 150 mm plus or minus 25 mm. All elements shall be galvanized.

E.7 Cable connecting hardware shall develop the full strength of the wire rope. At all locations where the cable is connected to a cable end with a wedge type connection, one wire of the wire rope shall be crimped over the base of the wedge to hold the cable firmly in place.

E.8 Restraining chains for G.R.E.A.T. impact attenuators shall be 12 mm nominal size and shall conform to ASTM A 413, Grade 28.

F. Glare Screens

F.1 Glare screen fabric shall be chain link mesh conforming to ASTM A 491 or ASTM A 392. Mesh sizes and wire diameters shall be as specified on the Drawings.

F.2 Posts shall be galvanized steel pipe conforming to ASTM A 153 and of the diameter shown on the Drawings. Posts shall be furnished with galvanized watertight caps.

F.3 Tension wire shall conform to ASTM A 641M (metric)- Class 1, Hard Temper, with a minimum diameter of 4.5 mm.

F.4 Tension cable shall conform to ASTM A 474 or A 475, 6 mm minimum diameter, high strength grade.

F.5 All hardware shall be typical of the types shown on the Drawings and shall be galvanized in accordance with ASTM A 153.

F.6 If shown on the Drawings, the fence fabric, posts and all exposed galvanized hardware shall be coated with a minimum 0.25 mm coating of bonded PVC. PVC shall be applied by the thermal extrusion process and shall withstand a minimum exposure of 1,500 hr at 62^{o}C without any deterioration when tested in accordance with ASTM D 1499.

F.7 Slats, when required, shall be either wood or plastic and of the dimensions shown on the Drawings. Wood slats shall be treated with a suitable preservative.

F.8 Plastic slats shall be tubular polyethylene, colour pigmented material consisting of high density polyethylene and colour pigments designed to retard ultraviolet penetration. The material shall have a minimum wall thickness of 0.7 mm and shall remain flexible without distortion and without becoming brittle through a temperature range of 0^{o}C to 60^{o}C.

F.9 Plastic slats shall be retained in place by means of U-shaped retainer members at the bottom and top of the glare screen. Retainer members shall be of the same material as the slats.

F.10 Samples for the colour of plastic slats shall be submitted for approval before use.

G. Bolts, Nuts, and Other Fittings

G.1 All bolts shall conform to ASTM A 307, except those designated on the Drawings as high strength, which shall conform to ASTM A 325 or A 449.

G.2 All nuts shall conform to ASTM A 563, Grade A or better, except those designated on the Drawings as high strength, which shall conform to ASTM A 563, Grade C or better.

H. Galvanizing

H.1 All of the exposed materials for guardrails, guardrail anchor terminals, impact attenuators, glare screens and delineators which consist of steel or iron shall be galvanized after fabrication unless otherwise specified. Whenever a galvanizing requirement is not included in the Specifications, it shall be in accordance with ASTM A 123 or ASTM A 153 as appropriate.

H.2 All components shall be fabricated and galvanized for installation without additional drilling, cutting or welding. When field modifications are approved by the Engineer or when minor damage to the galvanized coating occurs, the exposed surface shall be repaired by thoroughly cleaning and applying 2 applications of zinc dust-zinc oxide primer, as specified in Section 6.06: Painting of Structures.

I. Concrete

I.1 All concrete shall conform to the relevant requirements of Section 5.01: Concrete Mixes and Testing.

I.2 Unless otherwise shown on the Drawings classes of concrete shall be as follows:

- Concrete for post supports, buried footings and anchors shall be Class 170/60.
- Concrete for New Jersey concrete barriers and terminal sections shall be Class 360/20.
- All other concrete shall be Class 210/20.

J. Reinforcement

Reinforcing steel shall be of the size and type shown on the Drawings and shall conform to the requirements of Section 5.03: Steel Reinforcement.

K. Other Materials

Other materials shall be as shown on the Drawings. Special materials for impact attenuators shall be as specified by the manufacturer.

6.13.3 CONSTRUCTION AND INSTALLATION

A. Metal Beam and Cable Guardrail

A.1 Guardrail of the kind and type shown on the Drawings shall be constructed at the locations shown thereon and as determined by the Engineer.

A.2 All posts shall be set vertically in holes with the designated diameters and in the positions shown on the Drawings. Post holes shall be backfilled with cement mortar or concrete tamped into place as shown on the Drawings and when required by the Engineer.

A.3 Steel rail sections shall be cut, punched and/or drilled in the shop prior to galvanizing. Special detail holes shall only be cut in the field when necessary and if approved by the Engineer.

A.4 All nicks, gouges and scratches in the galvanized surface of the railing shall be painted with a high zinc content paint. The railing and posts shall be painted as described in Section 6.06: Painting of Structures.

A.5 Posts shall be installed by driving plumb to the required elevations or set in concrete, as shown on the Drawings.

A.6 If ground conditions are such that pilot holes are necessary to prevent damage to posts during driving, all space around steel posts after driving shall be filled with dry sand or fine gravel.

A.7 When posts are set in concrete, the concrete shall be placed against the face of the excavation unless otherwise approved by the Engineer.

A.8 Continuous lengths of rail or cable shall be installed and alignment checked and adjusted before final tightening of bolts. Unless otherwise specified, bolted connections shall be torqued to between 6 and 7 kg-m. Lapped rails shall be installed with the exposed ends away from the stream of traffic.

B. Pedestrian Guardrails

B.1 All prefabricated or ready-assembled pedestrian guardrails shall be welded in accordance with Section 5.16: Structural Steelwork and Metal Components

B.2 When directed by the Engineer and before fabrication has commenced, welding procedure trials shall be carried out using representative samples of materials to be used in the work.

B.3 During guardrail erection all members shall be securely held in their positions until the post fixings have gained sufficient strength to withstand the design load required. The assessment of the strength of the post fixing shall be subject to the Engineer's agreement. Finished guardrails shall be true to line throughout their length.

B.4 The rails and posts of pedestrian guardrails shall be closed sections presenting no visible seam welds or exposed bolt heads. The exact shape of the posts and rails shall be in accordance with the Drawings and to the approval of the Engineer.

C. Guardrail Anchor Terminals

C.1 Guardrail anchor terminals shall be installed as and where shown on the Drawings.

C.2 Posts, anchors and footings shall be driven or installed in concrete as required. Concrete shall be placed against the excavated earth unless otherwise approved by the Engineer.

C.3 Bolted connections shall be torqued as for guardrail bolts.

C.4 Cable guardrail end assemblies shall be attached to the breakaway anchor angle and turnbuckles tightened to provide the spring compression as shown on the Drawings. Backfill above the tops of concrete anchor footings shall not be placed before cables are tensioned. Cables shall be uniformly tensioned prior to bending tabs on end post caps.

D. New Jersey Concrete Barriers and Terminal Sections.

D.1 Concrete barriers shall present a smooth, continuous, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the Drawings and shall be free of lumps, sags, or other irregularities. The top and exposed faces of the barrier shall not vary by more than 6 millimetres between any 2 contact points when tested with a 4 metre straightedge laid on the surfaces.

D.2 Concrete barriers may be precast, cast in situ with fixed forms, or extruded with slip forms. Concrete barriers constructed by casting in situ using fixed forms, shall conform to the relevant requirements of Section 5.06: Reinforced Concrete Structures.

D.3 Unless otherwise shown on the Drawings, traverse expansion joints of 10 mm thick premolded filler shall be provided in all cast in-situ concrete barriers at a spacing not exceeding 15 metres centre to centre.

D.4 If concrete barriers are constructed using an extrusion machine or other similar type equipment, the concrete shall be thoroughly compacted and the exposed surfaces shall conform to the relevant requirements of Section 5.06: Reinforced Concrete Structures and as specified herein.

D.5 The Contractor shall furnish evidence of successful operation of the proposed extrusion machine or other equipment, by constructing a trial section of barrier or by other evidence acceptable to the Engineer.

D.6 Concrete shall be fed to the extrusion machine at a uniform rate. The machine shall be operated under sufficient uniform restraint to forward motion to produce a thoroughly consolidated mass of concrete free from surface pitting larger than 20 mm in diameter and requiring no further finishing. The concrete shall be of such consistency that, after extrusion, it will maintain the shape of the barrier without support. The grade for the top of the concrete barrier shall be indicated by an approved offset guide line.

D.7 The forming portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine to conform to the predetermined grade line. A grade line gauge or pointer shall be attached to the machine so that a continual comparison can be made between the barrier being placed and other established grade lines as indicated by the offset guide line. Other means of controlling barrier grades may be approved by the Engineer.

D.8 Expansion joints shall be constructed in the extruded concrete by sawing through the barrier section to its full depth. If sawing is carried out before the concrete has hardened, the adjacent portions of the barrier shall be firmly supported with close fitting shields. When sawing is carried out after the application of curing compound, the exposed faces of the barrier in the vicinity of the joint shall be treated with curing compound after sawing the joint.

D.9 If stationary forms for concrete barriers are used, they shall be removed as soon as possible after the concrete has set sufficiently to maintain the shape of the barrier without support. The surface shall be free from pits larger than 20 mm in diameter and shall be given a final soft brush finish with strokes parallel to the line of the barriers. Finishing with a brush application of grout shall not be permitted.

D.10 Concrete surfaces shall be finished as necessary to produce smooth, even surfaces of uniform texture and appearance, free of bulges, depressions and other imperfections. The use of power sanders, carborundum stones or disks may be required to remove bulges or other imperfections.

D.11 Exposed surface of concrete barriers shall be cured by membrane curing as specified in Section 5.02: Concrete Handling, Placing and Curing.

E. Impact Attenuators

Impact attenuators shall be installed as and where shown on the Drawings and in accordance with the manufacturer's recommendations and instructions. A copy of these recommendations and instructions shall be submitted to the Engineer upon delivery of the impact attenuator materials and before any installation commences.

F. Glare Screens

F.1 Glare screen fabric shall be placed on the face of the posts designated by the Engineer. On curves, the fabric shall be placed on the face of the posts on the outside of curves.

F.2 The fabric shall be stretched taut and securely fastened to posts as shown on the Drawings. Fabric shall be cut and attached independently at all pull and brace posts. Rolls of wire fabric shall be joined by weaving a single strand into the end of the rolls to form a continuous mesh between pull posts.

6.13.4 TESTING

A. Copies of all Certificates of Guarantee and test reports for all manufactured items shall be submitted to the Engineer.

B. Precast and in-situ concrete in foundations, New Jersey barriers and terminal sections shall be sampled and tested in accordance with Section 5.01: Concrete Mixes and Testing.

C. The Engineer may request additional sample materials for testing for strength, galvanizing, or other parameters.

D. Post fixing tests shall be carried out in accordance with manufacturer's recommendations, detailed on the Drawings or as instructed by the Engineer.

6.13.5 MEASUREMENT

A. Steel Guardrail, New Jersey Concrete Barrier and Glare Screen shall be measured by the linear meter furnished, installed completed and accepted. Measurements shall be based on the dimensions as shown on the Drawings. Terminal and Transition Sections shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract prices for Pay Items.

B. Impact Attenuators shall be measured by the unit of each type furnished, constructed or installed, completed and accepted.

C. Excavation, backfilling, concrete footings, anchors, lifting device, dowel bars and other ancillary items, shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which will be deemed to be included in the Contract prices for Pay Items.

SECTION 6.15: SITE INVESTIGATION

6.15.1 SCOPE

The work covered in this Section consists of the organization and execution of a site investigation survey, the testing and analysis of samples and the production of a comprehensive site investigation report.

6.15.2 PARTICULAR REQUIREMENTS

A. Type of Investigation and Report Required: A geotechnical investigation and report giving a full description of subsurface conditions, results of in situ and laboratory testing and recommendations. A detailed description of the surface conditions and features within the site shall be provided.

B. Description of The Site: The Contractor is responsible for his own interpretation of the geological site conditions within the project region.

C. Boreholes: Boreholes shall be drilled to the required depth specified by the Engineer on site. If rock is encountered, continuous coring shall be carried for a minimum of 7.5 m into good quality rock or as directed by the Engineer. Good quality rock is defined as rock with rock quality designation (RQD) value more than 75% for a core run of 1.0 m and a core recovery of not less than 90%.

D. Test Pits: Test pits shall be excavated to the required dimensions specified by and in the presence of the Engineer on site. Samples shall be taken for analysis and testing as directed by the Engineer.

E. In Situ Tests: Standard Penetration Tests are to undertaken in boreholes and test pits at the frequency or locations directed by the Engineer .

F. Laboratory Tests: The following tests shall be carried out as frequently as required, subject to the Engineer's approval, to describe adequately the natural variability in the soil deposit moisture content.

- Sieve analysis for granular materials.
- Mechanical analysis by sedimentation for fine materials.
- Dry and bulk densities of cemented and cohesive soil.
- Plasticity indices.
- Specific gravity.
- Chemical analysis of soil and ground water.
- Calcium carbonate content of soil or rock.
- Unconfined compression tests on cohesive soils.
- Unconsolidated undrained triaxial compression tests on cohesive soils.
- Consolidated undrained triaxial compression tests on cohesive soils.
- Consolidated drained direct shear (or triaxial) compression tests on cohesive soils.
- One dimensional consolidation tests on cohesive soils.
- Uniaxial compression tests on rock cores.
- Point load index of rock samples.

G. Responsibility: The Contractor is responsible for:

- The true and proper setting out of boreholes, test pits and test locations in relation to permanent reference points or bench marks.
- Accuracy of levels of boreholes and test pits.
- Accuracy of depth records to given bench marks on or near the site.
- Accuracy of his observations generally and for his reports on the observations.
- Accuracy of his calculations and interpretation.

H. Quality Assurance – Codes And Standards: The Contractor shall comply with provisions of following codes, specifications, and standards, except where more stringent requirements are shown or specified: BS EN ISO 14688-1:2002, BS EN ISO 14688-2: 2004, BS EN ISO 14689-1: 2003, BS EN ISO 22476-2: 2005 and BS EN ISO 22476-3: 2005.

I. Quality Assurance – Responsibility: When calculations, interpretations and recommendations are made the Contractor shall provide the names, qualifications and details of experience of those responsible and their position within the Contractor's organization.

J. Quality Assurance – Supervision: The Contractor's representative for the Site Investigation shall be a soils engineer, engineering geologist, or geotechnical engineer fully experienced in site investigation work. This specialist shall be on site full time for the duration of the site investigation readily available to attend to both the site investigation operatives and the Engineer.

K. Project Conditions – Services And Structures: Prior to excavation or drilling, where underground services or structures are believed to exist in the immediate vicinity of a borehole position or test pit, exploratory pits shall be excavated to such a depth to ensure that all underground services and structures are uncovered. The location of services and structures shall be clearly identified and sufficient clearance allowed for in a no-drilling zone to avoid damage.

L. Project Conditions – Pollution: The Contractor shall take sufficient measures to prevent fouling of the atmosphere, any river, stream, watercourse or sewer as a result of his activities. Provision shall be made for discharge or disposal from the work or temporary work of water waste products and spoil however arising. Methods of disposal shall be to the satisfaction of the Engineer and of any other authority or person having an interest in any land or watercourse over or in which water and waste products may be discharged. The requirements of this clause shall not limit any of the Contractor's statutory obligations or liabilities.

M. Position of Boreholes: The Contractor shall reference positions of boreholes and standpipes as installed from features of the site and record their co-ordinates in the Investigation Report.

N. Obtaining and Storing Samples: Methods of sampling and subsequent handling, labelling and storage of samples shall be in accordance with the applicable procedures described BS EN 14688-1:2002.

O. Submittals – Daily Borehole Records: daily borehole records shall be submitted to the Engineer not later than noon on the following day.

P. Daily Test Pit Records shall be submitted to the Engineer not later than noon on the following day.

Q. Daily Reports shall include weather conditions, work progress, difficulties and any oilier significant event.

R. Programme Of Laboratory Testing: A programme of laboratory testing shall be submitted to the Engineer for approval within 48 hours after completion of drilling and sampling for each borehole.

S. Geological Maps: The Contractor shall submit a detailed engineering geological map showing surface deposits whether naturally occurring or man-made at a scale agreed by the Engineer.

T. Draft Report: Two copies of the Draft Report in English including all the requirements detailed in Clause 6.15.3 below shall be submitted to the Engineer for approval at least six days before the end of the Contract Period. The Engineer shall inform the Contractor of any corrections or amendments within three working days of receipt of the draft.

U. Final Report: Four bound copies and one unbound copy of the accepted report, describing the work shall be produced in A4 size and shall contain the following factual information:

- Exploratory borehole records.
- In situ test records.
- Plots of all laboratory and in situ test results against depth.
- Laboratory test records and summaries.
- Plans with location of exploratory holes.
- Plan showing surface deposits/rock outcrops, fill, geologic features (Engineering Geological map).
- Bearing capacity, settlements and recommendations for slopes and foundations (type, level).
- Schedule of contents.
- Independently bound appendix of colour photographs of all rock cores, test pits and trenches and any oilier features relevant to the text and observations.
- Geological cross section(s) of the site.
- Sections through the boreholes showing the interpreted geological conditions.
- A description of the work undertaken with notes on any special situations or conditions relative to the work recommendations for foundation design and construction.
- Detailed design calculations and methods.

Soft copies using Excel version 5.0 or a later version shall be submitted in CD Rom format which shall include:

- All laboratory testing, in tabular and graphical form
- Summary tables of the laboratory testing results
- Soil and rock classification.

Soft copies of boreholes and test pit logs shall be submitted in Excel or other program acceptable to the Engineer. The soft copy of the text of the report shall be submitted in Microsoft Word Version 6.0 or a later version.

6.15.3 BORING AND SAMPLING

A. Boring Method

A.1 Boreholes shall be supported with casing as necessary to prevent collapse of the sides. Bentonite may be used subject to the approval of the Engineer as long as it does not interfere with sampling of soil or in-situ testing.

A.2 The contractor shall take all necessary measures to ensure that groundwater levels over the site are not affected by the borehole works and precautions shall be taken to prevent surface water entering boreholes.

A.3 Boring in soil shall be to a minimum diameter of 112 mm, unless otherwise directed by the Engineer, and undertaken either by shell and auger (cable percussion), wash boring or rotary power hollow stem auger methods to enable samples of at least 100 mm diameter to be obtained using open or piston samplers. Other drilling methods shall only be used if approved by the Engineer.

A.4 Unless otherwise specified for in-situ tests in boreholes, cores of not less than 76 mm diameter shall be obtained when drilling in rock by rotary coring methods.

A.5 Use of rotary percussion methods of drilling (down the hole hammer) or wash boring shall only be allowed with the approval of the Engineer.

A.6 Drilling fluid shall be fresh water or a mixture of water and bentonite if it is agreed with the Engineer that it is necessary to keep borehole sides stable. Use of sea water, air or air entrained foam or other fluids shall only be allowed with the approval of the Engineer and when it is the only means to obtain good quality samples.

A.7 When drilling over water, the Contractor shall provide a stable platform such as a stand up barge or floating platform and drill boreholes through guide pipes spanning between the working platform and the water bed. The design of staging, towers and platforms shall take into account fluctuating water levels due to tides, waves and swell conditions. Such construction shall be sufficiently strong for boring operations to resist waves, tidal flow and other currents and floating debris. Due consideration shall be given to safety requirements, navigational warnings and regulations of governmental departments and other authorities. Necessary readings of water levels and tidal gauges shall be made to enable sea bed elevations at locations of over-water boreholes to be referred to chart datum and elevations of various strata to be determined accurately.

A.8 If an obstruction is encountered which prevents further progress in boring by shell and auger or rotary power auguring, the Contractor shall attempt to break through the obstruction by chiselling. If the size or composition of the obstruction is such that little or no progress is made by chiselling, the Contractor shall inform the Engineer and if instructed and agreed, rotary coring methods shall be used to drill through and obtain cores of the obstruction of not less than 76 mm diameter.

A.9 If boring shows that the obstruction is bedrock, rotary core drilling shall be continued to the depth and diameter required by the Engineer to prove continuity and the engineering characteristics of formation.

A.10 If the boring shows that the obstruction is a boulder, ledge of rock or other object underlain by soil, the Contactor shall inform and agree with the Engineer the use of one of the following courses of action:

- Chisel out the cored borehole through the obstruction sufficient to allow shell and auger boring, in situ sampling and testing to continue below the obstruction
- Continue boring by rotary core drilling to the required depth and diameter of borehole and agree with the Engineer as to whether or not it is necessary to obtain undisturbed samples of soils in a nearby borehole at levels beneath the obstruction.
- Abandon the borehole and drill another one nearby to obtain the necessary samples.

B. Groundwater Observations

B.1 When groundwater is encountered in a borehole, the Contractor shall immediately cease boring and observe and record any movement in level of groundwater after half an hour. A standpipe or piezometer shall be installed on completion of borehole if specified or instructed by the Engineer.

B.2 In deeper aquifers the Contractor shall observe and record changes in water level, making records of groundwater levels, referring to the datum used for the work.

B.3 If casing is used and this forms a seal against entry of groundwater, the Contractor shall record the depth at which no further entry or only insignificant infiltration of water occurs.

B.4 If it is necessary to add water to the borehole to facilitate boring, it shall be used sparingly and shall not prevent accurate observation of groundwater conditions in the borehole.

B.5 The Contractor shall install standpipes in boreholes to the number and depths required by the Engineer. Standpipes shall comprise a rigid polyvinyl chloride or galvanized iron pipe of 45 mm minimum diameter, having at its lower end an approved porous filter element or perforated for a length of at least 500 mm. The filter or bottom of pipe shall have a surround of sand of a graded sand and gravel mix to prevent entry of soil particles into the pipe. A layer of the graded mix shall be placed in the bottom of the borehole prior to lowering the stand-pipe and before withdrawing the borehole casing. A screwed cap to the top of the standpipe, not less than 150 mm below ground level shall be provided. The cap shall be protected with a short length of 150 mm diameter pipe set vertically with the upper end covered by a paving slab set flush with the ground surface.

B.6 When instructed by the Engineer, the contractor shall fill the borehole above the filter with a layer of bentonite -cement grout. A plug of stiff bentonite shall be dropped into the borehole and carefully tamped into place, followed the pumped bentonite - cement grout to fill the borehole to a level of at least 0.5 metres above the filter or as instructed by the Engineer. A plug of bentonite-cement of a stiff plastic consistency shall be carefully tamped into place below the level of the standpipe to form a seal against the upward flow of groundwater into the standpipe from a deeper aquifer, if instructed by the Engineer..

Daily readings of water levels in all standpipes shall be taken. The frequency and duration of the readings shall be directed by the Engineer.

C. Soil Sampling

C.1 Undisturbed soil samples shall be obtained in all cohesive soils and mixed soils having sufficient cohesion at one metre depth intervals. The 200 mm of soil immediately above the level of soil to be sampled shall be removed without the casing being lowered. Boreholes shall be carefully cleaned before sampling.

C.2 Undisturbed samples shall be taken in seamless sampling tubes of not less than 100 mm internal diameter and 450 mm long designed so that samples can be sent to the laboratory without removal. The area ratio of sampling tubes shall be less than 15%.

C.3 The undisturbed sampling tool shall be lined with a coating of oil inside and out. The tool shall be sunk into the soil by jacking or, when this is not possible, by careful hammer driving. Care shall be taken when driving the tool to prevent soil becoming compressed in the sampler. Double tube or piston samplers shall be used if these prove to be the only means of obtaining acceptable samples. In soft clays particular care shall be taken to avoid disturbance to samples. In hard clays or cemented soils a Denison sampler or similar equipment approved by the Engineer shall be used.

C.4 Immediately after taking undisturbed samples from the boreholes a 25 mm thick layer from each end shall be removed and the ends sealed with a thick coating of paraffin wax or other wax approved by the Engineer. The 25 mm thick layers shall be transferred and stored in an airtight container for classification testing. The samples shall be sent to the laboratory suitably packed to prevent damage or disturbance. The samples shall be numbered and labelled so that all samples can be identified giving borehole, soil stratum, depth and date.

C.5 Standard penetration tests shall be undertaken as specified by the Engineer to recover a disturbed sample of soil at intervals of not more than one metre in the top five metres and at intervals of 1.5 metres or at the change of each strata thereafter.

C.6 Where undisturbed soil samples and standard penetration test samples are not obtained, disturbed samples of soils shall be recovered from boring tools. Disturbed samples shall be obtained at such spacing to ensure that samples from borehole either in the form of undisturbed samples, standard penetration test samples or disturbed samples are obtained for every 1 metre depth bored. The minimum weight of disturbed samples shall be as specified in BS EN ISO 14688.

C.7 Where bulk soil samples are required for compaction tests, the minimum weight of sample shall be 50 kg, unless otherwise instructed by the Engineer.

D. Coring

D.1 Continuous cores of all cemented material shall be extracted carefully to obtain a good recovery of weakly cemented material. The core barrel shall be fitted with a coring bit most suited to the formations being drilled and which yields the best recovery.

D.2 For coring in marl or other material that may be sensitive to water, compressed air shall be used as drilling fluid to obtain good samples.

D.3 Coring runs shall be limited to not more than 2 metres. If the core recovery is less than 80% the run shall be reduced until an acceptable recovery for subsurface conditions is obtained, as approved by the Engineer.

E. Rock Sampling

E.1 Where boreholes are drilled using rotary coring methods, rock cores of not less than 76 mm diameter shall be extracted, unless otherwise directed by the Engineer. After being brought to the surface cores shall be removed from the core barrel by methods designed to cause the least possible further disturbance.

E.2 Where split inner core barrels are not in use, cores shall be extracted core by steadily applied pressure. Extraction by hammering the barrel or explosive extrusion under high air or water pressures shall not be permitted. After extrusion cores shall be placed in a purpose made core box.

E.3 Cores shall be safely preserved, photographed and logged.

E.4 Core storage boxes be of sound, robust, watertight construction able to withstand the weight of cores and any full boxes which may subsequently be placed on them. They shall be purpose made to hold the size of core being obtained tightly and to be placed in rows separated by wooden slats. Boxes shall have strong metal hinged lids fitted with padlocks, hasps and staples for closing and end ropes for handling. The top and bottom of boxes shall be reinforced by cross straps to aid stacking and retrieval. Boxes shall be constructed of wood, marine plywood or other material approved by the Engineer.

E.5 Cores shall be laid in the core box with the shallowest core to the left and the deepest to the right. The highest core sample shall be placed nearest to the lid hinge. Boxes shall be identified inside and outside by the site name, borehole number, core box number, depth of top and bottom of core, the Contractor's name and the date. This information shall be either painted on box or stamped on metal labels waxed and nailed to the box.

E.6 The depth of the top and bottom of the total core and separate core runs shall be painted on blocks of wood or other material approved by the Engineer made to fit between dividing slots.

E.7 In order that zones of core loss can be readily identified wooden dowels cut to appropriate lengths and suitably identified shall be inserted either by the sections where loss occurred or at the base of the core runs.

E.8 Sections of core which are weak and friable, formed of rocks or soils which are likely to dry out or otherwise alter in nature with time shall be sealed with aluminium foil and subsequently covered with wax before placing in core box.

E.9 All cores shall be photographed as soon as possible after extraction. Photographs shall be free from distortion and shall include a scale and colour chart. All boxes shall be clearly labelled and show the depth to the top and bottom of each core run. Photographs and representative soil and core samples such as SPT or core shall be taken after extraction and prior to placing in plastic bags or core boxes. The samples shall be clearly labelled as described above.

E.10 Samples of soil and cores of rock shall be carefully transported from the site to the testing laboratory.

F. Soil and Rock Description

All soil and rock descriptions shall be in accordance with BS 5930:1999.

G. Groundwater Sampling

Samples of groundwater shall be taken as soon as sufficient water has entered the borehole after boring has reached groundwater level.

G.1 If water has been added to borehole before reaching groundwater level, all water in the borehole shall be extracted and uncontaminated groundwater allowed to seep back into the borehole before a sample is taken.

G.2 Where the groundwater is sealed off by a borehole casing and a lower aquifer is encountered a sample of water shall be taken from this and any succeeding aquifers.

G.3 Samples of groundwater shall be at least 500 ml in volume and placed in clean jars or bottles already rinsed with the water to be sampled, labelled and stored as described in BS 5930:1999.

6.15.4 COMPLETION AND BACKFILLING OF BOREHOLES

A. Backfilling of boreholes shall only commence after approval to proceed is given by the Engineer. Backfilling shall consist of soil placed in the borehole in layers, each successive layer being tamped by boring tools.

B. Backfilling shall be completed as the borehole casing is withdrawn.

C. When instructed by the Engineer boreholes shall be backfilled with concrete having a cement content of not less than 250 kg/m^3.

D. When instructed by the Engineer boreholes shall be backfilled with a bentonite /cement mix of an approved consistency.

E. When instructed by the Engineer boreholes shall be plugged where they might otherwise penetrate an artesian basin and lead to contamination of water in an aquifer.

F. Where boreholes are to be backfilled in areas of present or future underground water supplies the Contractor shall obtain advice from water authority concerned on the particular measures required to prevent pollution.

6.15.5 BOREHOLE RECORDS

A. The Contractor shall supply to the Engineer with a journal of each day's boring not later than noon on the following working day.

B. Where boring is to be completed by shell and auger or rotary power auger the journal shall state:

- Job name.
- Dates and times of boring.
- Borehole number.
- Ground level at position of boring.
- Type of plant used and method of boring.
- Diameter of boring.
- Diameter and depth of casings.
- All water levels encountered including measurements of fluctuation of adjacent tidal waters, lakes or rivers.
- Depths at which groundwater was sealed off.
- Level at which groundwater was standing at commencement and termination of working day (where a boring is on land but is near tidal waters the level of those waters is to be recorded at intervals throughout the day).
- Level at which water, if any, was added to borehole.
- Levels of water in standpipes.
- Depths of the base of each stratum from ground level and a preliminary description of the stratum.
- Records of in-situ tests made and instrumentation installed.
- Time taken for chiselling through obstructions and the weight of chisel.
- Other relevant remarks.

C. Where boring is to be completed by rotary coring methods the journal shall state:

- Job name.
- Date and times of boring.
- Borehole number.
- Ground level at position of boring.
- Type of plant used and method of operation including details of type of flushing.
- Type of core barrel and bit.
- Depths of holes at start and end of each working day or shift as relevant
- Depth of start and finish of each core run.
- Core diameter and changes in core size.
- State of bit.
- Time to drill each core run.
- Character and proportion of each flush return.
- Level at which groundwater was standing at commencement and termination of the working day (where a boring is on land but is near tidal waters the water level shall be recorded at intervals throughout the day).
- Depths of base of each stratum from ground level and preliminary description of strata.
- Total core recovery (TCR) defined as percentage of the rock recovered during a single core run, with information as to the possible location of core loss.
- Rock Quality Designation (RQD) of each run (RQD is the ratio expressed as a percentage of aggregate length of core pieces over 100mm in a run divided by the length of run).
- Solid core recovery defined as percentage of the full diameter core recovered during a single core run.
- Fracture Index defined as the number of fractures per unit metre.
- Details of in-situ tests and instrumentation installed
- Other relevant remarks.

D. Where boring is conducted on marine craft remarks shall also include:

- The level to which borehole data are to be referred.
- Time and height of high and low water at a tide gauge and tidal heights at intervals as directed by the Engineer.
- Time and height of water levels at borehole position at intervals as directed by the Engineer.
- Details of movement of water levels within borehole in relation to fluctuation of water levels at borehole locations.
- Detailed records of delays due to reasons other than failure of boring equipment (e.g. craft dragging anchors, mist, shipping movements and broken drilling tubes).
- Detailed records of movements, vibration and oscillation of drilling tubes
- Detailed records of bowing of drilling tubes because of waves, tidal currents etc.

E. After completion of all soil tests and visual examination of all samples in the laboratory, the Contractor shall prepare final borehole logs to include grid or topographical references and details similar to those in borehole records but corrected in the light of all information finally available and with descriptions by a qualified soils engineer or engineering geologist.

F. Where cores have been obtained by rotary drilling methods the final borehole logs shall state in addition to information given in borehole records:

- The condition of each core run in terms of percentage recovery and rock quality designation, i.e. percentage of solid core recovered in pieces longer than 100 mm.
- Definition of each rock type, its altered state and relative strength; details of natural discontinuities and rock structure and the nature of joint or fracture infilling.

G. The Engineer shall examine the borehole logs and shall, if he considers it necessary, instruct changes in the number, location and depth of boreholes. The Contractor shall not be entitled to modify his unit prices as a result of such changes.

6.15.6 IN-SITU TESTING

Standard Penetration Test

A. The Standard Penetration Test shall be performed at 1.0 metre intervals in the top 5 metres and at intervals of 1.5 metres and at the change of each stratum thereafter. If gravelly soil is encountered the standard penetration tool shall be fitted with a cone at its tip and the test carried out as normal. The standard penetration test sampler shall have an internal diameter of 35mm and an external diameter of 50 mm and shall be driven with a 63.5 kg hammer dropped through 0.76 metres. The hammer shall be dropped using a free-drop trigger release mechanism allowing control of the 0.76 metre drop. The bottom of the casing, if used, shall be stopped at test level, the borehole cleaned down to bottom of the casing and testing to start from that level down. Casings shall not be lowered during execution of the Standard Penetration Test.

B. The Standard Penetration Test shall be performed in accordance with BS EN ISO 22476-3:2005. Notwithstanding all precautions specified to avoid carrying out test in loosened soil, if there is good reason to believe that unrealistically low results are being obtained or soil flows into the borehole preventing testing being carried out, the Contractor shall report the matter to the Engineer and obtain his instruction regarding whether an alternative test is to be undertaken.

6.15.7 LABORATORY TESTING

A. The programme of laboratory testing shall be oriented towards obtaining data pertinent to the work. The programme and type of laboratory testing shall be submitted by the Contractor to the Engineer for approval.

B. Laboratory tests on soils shall be carried out in accordance with BS EN ISO 14688 or an approved equivalent where applicable and with the agreement of the Engineer.

C. The Contractor shall submit a report on laboratory tests containing the data required by the Specification for each test.

D. The Moisture Content Determination shall be expressed as a percentage of the dry weight of the soil to two significant figures.

E. The Sieve Analysis submittals shall include:

- The cumulative percentage by weight of soil passing test sieves after wet sieving and drying, plotted on a particle size analysis diagram
- The weight of samples tested.

F. The Particle Size Analysis By Sedimentation submittals shall include::

- The cumulative percentages as for sieve analysis plus percentage less than 0.2 mm, 0.006 mm and 0.002 mm plotted on a particle size analysis sheet.
- The loss of pretreatment to the nearest 1%.
- The weight of the sample tested.

G. The Density Test submittals shall include the bulk density and maximum and minimum density tests to be reported in Mg/m^3 to two decimal places

H. Plasticity Indices test submittals shall include::

- The history of the sample, i.e. the natural state, air dried or oven dried.
- The method used to obtain results.
- The percentage of material passing the ASTM sieve no. 40.
- The liquid limit expressed to the nearest 1%
- The plastic limit expressed to the nearest 1%
- The Plasticity Index.

I. The Unconsolidated Undrained Triaxial Compression Test: submittals shall include::

- The method used
- Whether the specimens were undisturbed or remoulded and the method of specimen preparation.
- The depth and orientation of specimen within the original sample.
- Initial and final dimensions of test specimens (mm).
- Descriptions of samples
- The bulk density (mg/m^3) to two decimal places.
- The natural moisture content to the nearest 1%.
- The cell pressure (kN/m^2).
- The rate of compressive strain to the nearest 1%.
- The thickness and type of membrane used and the correction applied.
- The maximum principal stress difference (kN/m^2).
- Time to failure.
- Deviator stress/strain curves.
- Mohr's Circle diagram for each set of three tests and the shear strength parameters.
- Orientation of the specimen with respect to the vertical.
- Sample description.
- Plasticity Index.
- Sketches to show modes of failure of specimens.

J. The Consolidated Undrained Triaxial Compression Test: submittals shall include::

- The method used
- Whether specimens were undisturbed or remoulded and the method of specimen preparation.
- Depth and orientation of the specimen within the original sample.
- Initial and final dimensions of test specimens (mm).
- Bulk density (Mg/m^3) to two decimal places.
- A description of each sample.
- Whether side drains were fitted.
- Method of saturation and the pore pressure and value of pore pressure coefficient B at the end of saturation.
- Cell pressure, back pressure pore pressure dissipation at the end of consolidation.
- Pore pressure and percentage pore pressure dissipation at the end of the consolidation phase.
- A plot of volume change, cm^3 (or volumetric strain) versus the square root of time for the consolidation phase.
- Rate of axial displacement applied to the specimen (mm/min or %/hr).
- Pore pressure and effective stress at the start of the compression stage.
- The failure criterion adopted.
- Axial strain, deviator stress, pore pressure and effective major and minor principal stresses at failure.
- Effective principle stress ratio at failure.
- A sketch of the specimen after testing, indicating mode of failure.
- Details and magnitude of corrections applied.
- Final density and moisture contents.
- Curves of deviator stress versus axial strain.
- Curves of pore pressure versus axial strain.
- Curves of effective principle stress ratio versus axial strain.
- Elastic modulus
- Mohr's Circle for each set of three tests and effective and the total shear strength parameters.

K. The Consolidated Drained Triaxial Compression Test samples shall be drained during shear and the rate of shearing is to be such that no excess pore pressure is generated during the shearing. The submittals shall include::

- The method used.
- Specific gravity.
- Initial water content.
- Final water content.
- Initial thickness.
- Final thickness.
- Specimen thickness change.
- Whether undisturbed or remoulded specimens and the method of specimen preparation.
- Depth and orientation of specimen within the original sample.
- Initial and final dimensions of test specimens (mm).
- Bulk density (Mg/m^3) to two decimal places.
- Description of sample.
- Description of types of shear devices (including whether side drains are fitted).
- Method of saturation and pore pressure and value of pore pressure coefficient B at the end of saturation.
- Cell pressure, back pressure pore pressure dissipation at the end of the consolidation.
- Pore pressure and percent pore pressure dissipation at the end of the consolidation phase.
- Plot of volume change, cm^3 (or volumetric strain) versus the square root of time for consolidation phase.
- Rate of axial displacement applied to the specimen (mm/min or %/hr)
- Pore pressure and effective stress at the start of the compression stage
- Failure criterion adopted.
- Axial strain, deviator stress, pore pressure and effective major and minor principal stresses at failure.
- Effective principle stress ratio at failure.
- A sketch of the specimen after test, indicating mode of failure.
- Details and magnitude of corrections applied.
- Final density and moisture content
- Curve of deviator stress versus axial strain.
- Curve of pore pressure versus axial strain.
- Curve of effective principle stress ratio versus axial strain
- Elastic modulus.
- Mohr's Circles for each set of three tests and effective shear strength parameters.

L. The Consolidated Drained Direct Shear Compression Test submittals shall include:

- The method used.
- Specific gravity.
- Initial water content.
- Final water content.
- Initial thickness.
- Final thickness.
- Specimen thickness change.
- Whether undisturbed or remoulded specimens, and the method of specimen preparation.
- Depth and orientation of specimen within original sample.
- Initial and final dimensions of test specimens (mm).
- Bulk density (Mg/m^3) to two decimal places.
- Description of sample.
- Description of type of shear device.
- Specific gravity.
- Initial water content.
- Final water content.
- Initial thickness.
- Final thickness.
- Specimen thickness change.
- Void ratio.
- Normal stress shear displacement.
- Shear resistance value.
- A plot of the maximum shear stress verses normal stress for each sample.
- A plot of the shear stress and specimen thickness change verses shear displacement.
- If any departure from procedure outline was performed (such as special loading sequence or wetting etc).

M. The Unconfined Compression Test on Soil submittals shall include:

- The method used:
- Dimensions of specimen (mm)
- Bulk density (Mg/m^3)
- Moisture content to nearest 1%.
- Compressive strength to the nearest 2 kN/m^2 for values up to 50 kN/m^2, to the nearest 5 kN/m^2 for values of 50-100 kN/m^2 and to the nearest 10 kN/m^2 for values over 100 kN/m^2
- Shear strength (kN/m^2) to two decimal places.

N. Consolidation Test submittals shall include:

- The method used:
- Initial and final thickness of specimen to nearest 0.002 mm.
- Initial moisture content.
- Initial bulk density (Mg/m^3) to two decimal places.
- Specific gravity of soil particles.
- Graph of the voids ratio versus the logarithm of applied effective stress.
- Graph of compression (mm) versus the square root of time or logarithm of time (min).
- Coefficient of compressibility (m^2/MN) for a minimum of four pressure increments including at least one pressure greater than the pressure increment from expected loading.
- Compression ratios and the coefficient of consolidation (m^2/year) for a minimum of four pressure increments including at least one pressure greater than the pressure increment from expected loading.
- Orientation of the specimen with respect to the vertical
- A detailed description of the specimen.

O. Specific Gravity of Soil Particles test submittals shall include:

- The method used:
- The specific gravity of soil particles to the nearest 0.01.

P. For the Sulphate Content of Soil test, the Contractor shall submit the water soluble sulphate content of soil expressed as the percentage of sulphur trioxide or in grams per litre when determined from a 1:1 aqueous extract.

Q. For the Calcium Carbonate Content of Soil test, the Contractor shall submit the calcium carbonate content to nearest 1% by weight of the original direct sample.

R. For the pH Value of Soil the Contractor shall submit the pH values accurate to 0.1.

S. For the Chloride Content of Groundwater the Contractor shall submit the concentration expressed in mg/1.

T. For the Sulphate Content of Groundwater: the Contractor shall submit the sulphate content of groundwater expressed as parts per million.

U. For the Chloride Content of Groundwater: the Contractor shall submit the chloride content of groundwater expressed as parts per million.

V. For the pH Value of Groundwater the Contractor shall submit pH values accurate to 0.1.

W. The Uniaxial Compression Test for Rock submittals shall include:

- Physical descriptions of samples including rock types, location and orientation of apparent weakness planes, bedding planes, large inclusions or homogeneities.
- Dimensions of specimens (mm).
- General indication of moisture condition of samples at time of test.
- Type and location of failures.
- Uniaxial compressive strengths to the nearest 50 kN/m^2.

X. Point Load Test submittals shall include point load strengths corrected to that of a 50 mm core to the nearest 50 kN/m^2, raw data, dimensions of specimens, correction procedures and correlations used to deduce the unconfined compression strengths.

Y. The standards and equipment used for other laboratory tests required shall be agreed with the Engineer as well as the procedures and results to be submitted.

6.15.8 MEASUREMENT

A. GENERAL

Unless otherwise stated in Bill of Quantities or herein, the costs of the following are deemed to be included with the work, as applicable. Rates and prices inserted by the Contractor against the work items in the Bill of Quantities, shall be deemed to cover such costs:

- Labour and all costs in connection therewith.
- Materials, products, goods, supplies, consumables and all costs in connection therewith.
- Contractor's equipment, including but not limited to: plant, machinery, tools, vehicles and all costs in connection therewith.
- Temporary works and all cost in connection therewith, including but not limited to: installing, maintaining, adapting, clearing away and making good as necessary.
- Work at any location or depth.
- Work in small, isolated quantities.
- Protection of all work.
- Protection of all existing structures, utilities, site improvements, trees and vegetation, features, pavements and other facilities on and adjacent to the site, which are to remain upon completion of the work.
- All other enabling tasks, associated and subsidiary components and items of work, which are indicated or reasonably inferred from the Drawings and/or the Specification, and which are necessary to perform and complete the work described.
- Establishment costs, overhead charges and profit.
- On-site and off-site supervision and management.

- Site administration and security.
- Insurances, bonds and guarantees.
- Water for the works
- Lighting and power for the works.
- Temporary access, hard standings, crossings and the like.
- Temporary fencing, hoardings, screens, foot-ways and the like.
- Giving notices and making applications, including the payment of fees and charges in connection therewith.
- Safety, health and welfare of workpeople.
- Compliance with traffic regulations.
- Maintenance of public and private roads, services and adjoining property.
- Control of noise and pollution, prevention of fire and compliance with all other statutory and general obligations.
- Clearance and removal from the site of all Contractor's rubbish, debris and surplus excavated material, and upon completion of the Works, the reinstatement and restoration of the site to its original condition.
- Providing equipment for testing.
- Preparation and submittal of reports, drawings, records, certificates, notices, proposals, designs, details, calculations and other information and data required by the Specification.
- Compliance with all other requirements, provisions, responsibilities and obligations contained in the Contract Documents.

B. SUBSURFACE INVESTIGATION

B.1 Mobilization

B.1.1 If there is no separate rate for Mobilization in the Bill of Quantities either for on-shore and off-shore works then the associated costs are deemed to be included in the rates for the other associated work items. Rates and prices inserted by the Contractor against the work items in the Bill of Quantities shall be deemed to cover for such work.

B.1.2 The rate for Mobilization, if included in the Bill of Quantities, is deemed to include:

- Bringing to and providing on-site all Contractor's equipment, accommodation, messing facilities and temporary works materials necessary to undertake the works.
- Carrying out enabling tasks and providing all temporary works and services necessary to commence, perform and complete the Works.
- Demobilizing the site upon completion of the Works, including but not limited to: removing from site all Contractor's Equipment and temporary works materials, clearing and removing from the site all Contractor's rubbish, debris and surplus excavated material, and reinstating and restoring the site to the original condition.

B.2 Drilling and Coring

B.2.1 Drilling and coring boreholes items shall be measured in metres. Drilled lengths are measured from the top to the bottom, along the axis of the relevant borehole. The top of the borehole is the natural ground or the sea bed.

B.2.2 Work is deemed to include:

- Accessing borehole locations.
- Setting out borehole locations and providing coordinates.
- Excavating exploratory pits to determine the existence or otherwise of any underground services, utilities or structures at, or in the vicinity of borehole locations.
- Backfilling exploratory pits.
- Erecting drilling rig and equipment at borehole locations, including but not limited to: assembling, maintaining and adapting as necessary; dismantling upon completion and moving from location to location as required.
- In-situ testing (refer to Clause 6.15.6)
- Drilling or coring vertical or inclined boreholes.
- Providing temporary support for sides of boreholes.
- Drilling through any material (except rock), including artificial obstructions.
- Coring through rock.
- Taking both disturbed and undisturbed soil samples and photographs.
- Taking continuous core samples.
- Observing ground water levels and taking ground water samples, carrying out standard penetration, and pocket penetrometer tests, backfilling boreholes upon completion of the work, providing daily records and borehole logs.
- Installing standpipe equipment, materials, filters, screens and instruments, etc., and maintaining for as long as is necessary.
- Monitoring water levels at intervals as directed
- Taking water samples as directed.
- On completion of the work, reinstatement of the borehole working area and access routes thereto, to the original condition and to the satisfaction of the Engineer.

B.3 Test Pits

B.3.1 Excavation of test pits is measured per number excavated. The dimensions of the excavation shall be measured from the top surface to the base of the excavation as specified on the Drawings, indicated in the Bill of Quantities or instructed by the Engineer. The top surface is the natural ground level. Additional excavation in test pits due to overbreak of rock or other reason shall not be paid for separately and the costs shall be deemed to be included in the rate for excavation.

B.3.2 Work is deemed to include:

- Accessing test pit locations.
- Setting out test pit locations and providing coordinates.
- Excavation to the depths and dimensions specified.
- Over- excavation and overbreak
- Providing temporary support for the sides of the excavations.
- Excavation though rock using cutting and breaking tools as necessary
- Taking measures to protect services uncovered through excavation, including temporary supports, repairs and reinstatement to the satisfaction of the service provider
- Taking both disturbed and undisturbed soil samples and photographs.
- Dewatering of excavation
- Carrying out standard penetration, and pocket penetrometer tests
- Backfilling excavations upon completion of the work
- Providing daily records and test pit logs.
- Monitoring water levels at intervals as directed
- Taking water samples as directed.
- On completion of the work, reinstatement of the test pit working area and access routes thereto, to the original condition and to the satisfaction of the Engineer

B.4 Laboratory Testing

B.4.1 Laboratory testing includes mechanical and chemical tests. These tests are enumerated, and the types are listed below:

Mechanical Tests

(1) Sieve analysis (including moisture content determination)

(2) Particle size analysis by sedimentation for fine materials (including moisture content determination)

(3) Specific gravity /density testing

(4) Plasticity indices

(5) Unconsolidated undrained triaxial compression tests on cohesive soils

(6) Consolidated undrained triaxial compression tests on cohesive soils

(7) Consolidated drained triaxial compression tests on cohesive soils

(8) Consolidated drained direct shear compression tests on cohesive soils

(9) Unconfined compression tests on soils

(10) One dimensional consolidation tests on cohesive soils

(11) Uniaxial compression tests on rock cores, including bulk density, moisture content, and Young's Modulus determination

(12) Point load index of rock samples

(13) Optimum moisture content

Chemical Tests (Analysis of Soils and Groundwater)

(14) Sulphate content

(15) Chloride content

(16) PH value

(17) Calcium carbonate content of soil or rock

B.4.2 Work is deemed to include:

- Moving test equipment from location to location as required.
- Setting up test equipment, carrying out tests and recording the data.
- Providing the data.
- Handling, packing, protecting and transporting soil, rock and water samples to the laboratory.
- Carrying out specified tests in accordance with an approved programme.
- Reporting of tests results.

B.4.3 Laboratory tests shall be measured by number of the aforementioned listed tests, completed as directed submitted and accepted.

B.5 Report

B.5.1 Work is deemed to include the preparation and submittal of a complete and full report document(s), incorporating drawings, records, results, certificates all other information and data required by the Specification; including but not necessarily limited to:

- Reporting of all excavation and drilling and of on site and laboratory testing.
- Borehole logs.
- Production of engineering geological maps and cross-sections.
- Bearing capacity, settlements and recommendations for slopes and foundations (type, level).
- Providing hard and soft copies as specified.
- Photographs.

B.5.2 Preparation and submittal of each report shall be measured per item, incorporating all the draft and final copies specified or as instructed by the Engineer.

SECTION 8: DRAINAGE, SEWER AND WATER SUPPLY NETWORKS

SECTION 8: DRAINAGE, SEWER AND WATER SUPPLY NETWORKS

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SECTION 8.01 DRAINAGE, SEWER AND WATER SUPPLY NETWORKS: GENERAL REQUIREMENTS

8.01.1 SCOPE

A. The work covered in this section includes the supply of materials, installation, testing and commissioning of all pipes, fittings, valves, and appurtenances related to:

- The provision and construction of a stormwater drainage network including pipes, ditches, manholes, catchpits, catch basins, interceptors, access shafts, discharge points and connections to existing culverts.
- The provision and construction of wastewater collection networks including pipes, manholes and connections to existing sewers.
- The provision, construction and connection of water supply networks including pipes, valves, couplers and all other accessories.

B. The work consists of finishing all materials and the construction installation and completion in all respects as described in this Specification and as shown on the Drawings.

8.01.2 SPECIAL REQUIREMENTS

A. **Manufacturer's Certificate**: Materials shall be supplied with a certificate, in respect of each delivery, stating that products comply with and have been factory tested in accordance with the specified Standards.

B. **Marking**: Unless otherwise specified in the relevant Standard, products shall have legibly cast, stamped or indelibly painted on, the following marks, as appropriate:

- The manufacturer's name, initials and identification mark.
- Nominal diameter.
- Class designation.
- Initials and number of relevant Standard.
- Length of pipe if shorter than the standard length.
- Angle of bends in degrees.
- The date of manufacture.

C. Special Tests: Whenever required by the Engineer, the Contractor shall supply and transport to an approved testing laboratory samples of materials selected by the Engineer. The number of samples shall not be less than 0.5% of total supplied, with at least one from each class, diameter and manufacturer. Failure of any sample shall be followed by a second and if necessary a third test from the same batch. A third test failure will result in all material from that manufacturer being rejected and replaced by material from a different manufacturer, subject to approval by the Engineer, after satisfactory testing. Laboratory test reports in an approved form shall be provided.

8.01.3 WORKMANSHIP: OPERATIONS

A. Manufacturer's recommendations on handling, repairing, laying, jointing, anchoring, testing and other works for pipes and fittings shall be strictly followed.

B. The Contractor shall use cranes, hoists or forklifts as directed by the Engineer. The Contractor shall use hooks, spreader beams, ropes, band or wire slings etc. as recommended by the manufacturer for each type of pipe and as approved by the Engineer.

C. The Contractor shall stack pipes on a level surface. Pipes shall not rest on sockets or flanges and end pipes in the bottom row shall be securely chocked. Heights of stacks shall be in accordance with the manufacturer's instructions.

D. The Contractor shall handle material with care to avoid damage whenever moved by hand, forklifts or hoists.

E. The Contractor shall provide safe storage for all material. The interior of pipes, fittings etc. shall be kept free from dirt and foreign matter. The Contractor shall provide shade for materials as required by manufacturers' instructions and recommendations and to the Engineer's approval.

F. Cutting: The Contractor shall use hacksaws, manually operated wheel cutter or pipe cutting machine in accordance with manufacturers' instructions. If, in the opinion of the Engineer, special precautions are required to eliminate airborne particles, the Contractor shall use methods and equipment as directed by the Engineer. The Contractor shall prepare ends according to type of joint used and follow manufacturers' recommendations. The Contractor shall take care not to damage linings. The Contractor shall repair on site minor damage if so permitted by the Engineer.

G. The Contractor shall repair damaged coatings, sheathings or linings in accordance with the Specification and the manufacturer's instructions. The Contractor shall use material compatible with that originally used. Repairs shall be approved by the Engineer before incorporating the materials into the works.

8.01.4 SEQUENCE OF CONSTRUCTION

The Contractor shall adhere to the sequence of construction as set out below unless a justified request for modification is approved by the Engineer at least two weeks prior to commencement of work on the affected section of the network:

- Stake out pipe alignments
- Clear and grade the right of way (wherever required)
- Carry out surveys, including trial pits if necessary, along the alignments to verify the location, depth, size and type of existing utilities.
- Prepare and submit for approval composite Shop Drawings for all utilities showing alignment, ground elevation, trench invert elevation, pipe size, class and length, station and size of fittings, valves as applicable manholes, inlets, appurtenances and structures to be demolished and reinstated (kerbstone, rails, culverts, etc.). Cross sections showing location and inverts of existing pipes and those proposed shall be prepared. Pipes, structures and other utilities to be removed or relocated shall be indicated on the Shop Drawings.
- Relocate, demolish and reinstate existing services and utilities interfering with pipeline alignments.
- Remove pavement layers, excavate trenches and place bedding as required
- Lay and join pipes, fittings, appurtenances, manholes, etc.
- Place primary backfill material
- Perform hydrostatic testing
- Complete connections to existing services and curb/gutter inlets as required
- Place final backfill
- Restore or reinstate surfaces and structures as required
- Carry out final surface works road surfacing curb stone, backing walls, sidewalk paving, etc.
- Dispose of surplus materials.

8.01.5 RIGHT OF WAY

A. Extent

A.1 All utility services shall be installed in the right-of-way of existing or proposed roads as shown in the Drawings, typical cross sections and the utility provider’s requirements.

SECTION 8.02 PIPES AND APPURTENANCES

8.02.1 SCOPE

A. The work covered in this section includes furnishing and installing pipes for surface water drains and sewers as and where shown on the Drawings including jointing, connections to other pipes and drainage structures and backfilling.

B. Drainage, sewer and water supply work shall be in accordance with the requirements of Section 8.01 of the Specification.

8.02.2 MATERIALS

A. Concrete Pipes (for Sewage and Drainage)

A.1 Precast concrete pipes shall be manufactured in accordance with BS EN 1916: 2002 Class H. Cement used in manufacture shall be Ordinary Portland Cement to BS EN 197-1:2000.

A.2 Joints shall to be the gasket type with flexible spigots and sockets. The shape of the joint shall be designed to prevent any movement of the gasket during assembly and to be watertight. Rubber gaskets shall be manufactured to BS EN 681-2:1996.

A.3 The inside faces of pipes for sewer networks shall be lined as follows:

- For pipes smaller than 900 mm diameter a coal tar epoxy coat 70% minimum epoxy content shall be used. The minimum thickness of the coat shall be 1mm.
- For pipes 900 mm and larger a polyethylene liner shall be used.

A.4 For internal and external faces of concrete pipes for drainage networks and external faces of concrete pipes for sewer networks linings are not required.

B. Ductile Iron Pipe (for Water Supply)

B.1 Pipes shall be manufactured to BS EN 545:2002. Unless otherwise indicated in the Bill of Quantities. Class K9 pipes shall be used for diameters up to 500 mm, Class K8 for diameters from 500 to 800 mm and Class K7 for diameters greater than 800 mm.

B.2 Spigot and socket ended pipe joints shall be used for straight runs and adjacent to elbows or fittings. These joints shall be provided with rubber gaskets, and external thrust blocks at elbows or fittings. Anchored or self restrained joints shall be used for sections on 1000 mm pipes adjacent to elbows. Anchored joints shall be the push-in, self anchored type. Concrete thrust blocks are not required for anchored joints. The Contractor shall submit calculations verifying the number of restrained joints required noting that pipe pressure testing will be made when pipes are partially backfilled.

B.3 Joints: flanged pipes wherever specified shall have screwed-on or cast-on flanges to sustain a minimum working pressure of NP 16 minimum.

B.4 Flanges shall be provided in accordance with BS EN 1092-1:2002.

B.5 Factory protection for pipes shall be as follows:

- Internally: cement lined to BS EN 545:2002 with ordinary Portland cement to BS EN 197-1:2000 to the thickness specified on the Drawings or as instructed by the Engineer.
- Externally: metallic zinc shall be applied in accordance with BS EN 545:2002 either hot applied coal tar material to BS 4164:2002 or bitumen to BS 3416:1991, minimum thickness 150 microns.

B.6 Factory protection for fittings shall be as follows:

Coated internally and externally by dipping, or other method, using hot applied coal tar based material to BS 4164:2002 or hot applied bitumen to BS 3416:1991, Type 1, grade D, minimum thickness 250 microns.

C. UPVC Pipes

C.1 Pipes shall be manufactured in accordance with DIN 8061/8062, Series 4 and 5 or ISO 161-1:/4422 Class 10 and & 16. Concrete encasement shall be used if the cover is less than 1.2 metres.

C.2 Fittings shall be manufactured in accordance with DIN 8063 part 1 fabricated from pipe.

C.3 Joints shall be manufactured in accordance with DIN 8063 Part 1, socket spigot with rubber sealing rings to BS EN 681-1:1996.

D. Polyethylene (PE) Pressure Pipe for Water Supply and Irrigation

D.1 Pipe and fittings shall be manufactured in accordance with DIN 8074/8075 or AWWA C906-99. Pipes shall be supplied straight with straight ends suitable for heat fusion, class 10 and 16 kg/cm^2.

D.2 Materials used shall have a minimum hydrostatic design basis of 1600 psi according to AWWA C906-99 Table 1.

D.3 Manufacturers shall provide certification that stress regression testing has been performed on the pipe products. Materials shall also meet elevated temperature requirements as given in Table 2 AWWA C906:99.

D.4 Fittings shall be manufactured in accordance with AWWA C906-99, extruded or injection moulded suitable for the class of pipe required.

D.5 Joints for pipes and fittings shall be made by heat fusion and in strict accordance with the pipe manufacturer's recommendations. Joints shall have a tensile strength equal to that of the pipe. Fusion temperature, interface pressure, alignment and cooling time, shall be according to the manufacturer's recommendations.

D.6 Where PE pipes are to be used for potable water supplies, PE compounds in pipes and fittings shall contain no toxic chemicals that can migrate into the water. PE compounds shall be tested and certified suitable for potable water by an accredited testing agency as approved by the Engineer. Tests shall be undertaken in accordance with requirements no less restrictive than those in NSF Standard No. 14 (1976), Sections 3 and 4. The seal and mark of the testing laboratory shall be included on pipes and fittings.

E. Glass Reinforced Plastic (GRP) Pipes

E.1 GRP pipes and fittings shall be manufactured in accordance with BS 5480:1990. Resins, surface tissues and fibrous reinforcement shall be in accordance with clause 3; pipes and fittings shall be supplied with a resin rich corrosion liner consisting of a layer of 'c' glass backed by a layer of 'E' glass impregnated with resin - with a nominal thickness of 1.0 mm and an outer layer with a minimum thickness of 0.2 mm. The sand content shall not exceed 50%. GRP pipes shall have the following properties: -

- Stiffness: minimum 5000 N/m^2. Suitability of stiffness shall be verified by Contractor for the various trench and pipe laying conditions and as recommended by the manufacturer.
- Longitudinal strength: to BS 5480:1990 table 2.
- Strain corrosion resistance: tests are to be carried out in accordance with BS 5480:1990 with a strain corrosion value at 50 years to equal or exceed 0.7%.
- Markings: to BS 5480:1990 clause 11.
- Joints: GRP double socket couplings or bell and spigot type with rubber rings to BS EN 681-1:1996. Allowable angular deflection shall be in accordance with BS 5480:1990 Table 3.

E.2 Testing on GRP pipes: The following tests shall be carried out on manufactured pipes. Details of the testing programme shall be submitted to the Engineer for review and approval prior to commencement of pipe manufacture. The manufacturer quality control scheme shall be to BS EN ISO 9001:2000. Guidance on quality control and sampling shall be BS 5480:1990 Appendix Q. The following tests shall be carried out in accordance with BS 5480:1990 and reported to the Engineer for approval.

- Longitudinal strength
- Hydraulic test.
- Stiffness
- Wall thickness
- Diameter
- Hardness
- Loss of ignition

F. Steel Pipe

F.1 Steel pipes of size 150 mm and smaller shall be black steel, seamless or welded, and shall conform to BS 1387:1985 medium class, or ISO 65:1981.

F.2 Steel pipes of size 200 mm and larger shall be welded black steel, and shall conform to BS EN 10216:2002 or BS EN 10217. Minimum wall thickness shall be in accordance with to BS EN 10220:2002 or as given in the Bill of Quantities.

F.3 Steel pipe shall be round and straight and free from injurious defects. Defects shall be considered injurious when the depth of defect is greater than 12.5% of the tabulated wall thickness. Pipe shall be free from rust.

F.4 Steel pipe shall be joined by double submerged arc welding in accordance with BS EN 10311:2005. All welding shall be performed in conformance with the rules and regulations of the American Welding Society, including surface preparation methods, welding procedures and the qualification of welders and welding operators.

F.5 Surface preparation: Prior to coating, the surface shall be prepared by acid pickling until all scale has been removed.

F.6 Internal lining: All steel pipes and specials shall be lined internally to the thickness specified with concrete made from ordinary Portland cement to BS EN 197-1:2000 and fine aggregate. The materials used for lining, the method of lining and curing of the finished lining and the manufacture and testing of test cubes shall comply with BS EN 10224:2002 and shall be carried out to the approval of the Engineer.

F.7 External coating: steel pipes fittings and specials shall be protected externally with bituminous laminate tape 1.6 mm thick and with a 55% overlap or as recommended by the manufacturer.

G. Flanged Adaptors: Ferrous

G.1 Ferrous flanged adaptors shall be manufactured in accordance with BS EN 545:2002 from cast iron to BS EN 1561:1997 grade 14 or mild steel plate to BS EN 10210 4SA and malleable cast iron flanges to BS EN 1562:1997 310 grade 20/10 or rolled steel to BS EN 10084 - 060A12 with bolts to BS EN 10084:1998 - EN3A and rubber rings to BS EN 681-1:1996.

G.2 The lengths of adaptors shall be 200 mm for diameters up to 150 mm, 250 mm for diameters between 200 and 300 mm and as approved by the Engineer for diameters larger than 300 mm.

G.3 Factory protection: Adaptors shall be coated with bitumen or coal tar to BS 3416:1991 or BS 4164:1987 respectively.

H. Tapping Saddles: Cast Iron

H.1 Type: Tapping saddles shall be suitable for tapping ductile iron pipe and for a working pressure of 16kg/cm^2.

H.2 Material: Saddles shall be manufactured from malleable cast iron, ductile cast iron or gunmetal to BS EN 1562:1997 310 - B310/10, BS EN 1563: 1997 - 420/2 or BS EN 1982:1999 LG2- C respectively, with rubber '0' ring to BS EN 681-1:1996 suitable for water supplies and manganese bronze high tensile non- corrosive bolts, nuts and washers.

H.3 Dimensions: saddle widths shall not be less than 38 mm and diameter of discs not less than 75 mm.

H.4 Threads for tapping shall be manufactured in accordance with BS EN 10226-1:2004

H.5 Factory protection shall be hot bitumen dipped to BS 4164:2002 or cold bitumen coated to BS 3416:1991.

8.02.3 WORKMANSHIP

Earthworks for pipelines shall be constructed in accordance with Section 2.10 of the Specification.

A. Pipe Laying and Jointing - General

A.1 Pipes shall not be lowered into trenches until the pipe bed is brought to grade and approved by the Engineer.

A.2 Pipes shall be lowered using ropes, wire slings, band slings and spreader beams as recommended by the pipe manufacturer for each type of pipe and approved by the Engineer.

A.3 All materials shall be examined for damage. Tests shall be undertaken in accordance with the manufacturer's instructions and to the satisfaction of Engineer before installation.

A.4 The Contractor shall ensure that all internal coatings and linings and outer coatings or sheathing are undamaged. Damaged areas shall be made good or disposed of as directed by the Engineer.

A.5 Dirt and other materials shall be removed from pipes before lowering.

A.6 Construction debris shall be cleared from the inside of pipes before making joints.

A.7 Pipes shall be laid on an even formation true to grade and line, with sockets (if any) facing up the gradient.

A.8 Holes shall be cut in the trench formation to allow for correct jointing and for barrels of pipes to bear evenly on solid ground for their full length.

A.9 Bedding material shall be scooped out locally at sockets/couplings to enable pipes to rest uniformly on barrels and adjusted to the exact line and level. After testing, granular surround material shall be laid and compacted in 150 mm layers or as directed by the Engineer to levels shown on the Drawings.

A.10 Rectangular blocks of concrete Class B shall be provided for pipes on concrete bed or surround. The blocks shall be made in approved moulds at least 14 days before use with hardwood folding wedges. Two concrete blocks shall be provided for each pipe, set and boned to the correct level on the formation and the pipe laid centrally and socketed. Two hardwood folding wedges shall be inserted, of widths equal to the width of the concrete blocks, between the body of the pipes and blocks and driven together until the pipes are brought to the exact level required. Blocks and wedges shall be left undisturbed while pipes are being jointed and the concrete bed and haunch or surround are being placed. Blocks and wedges shall be of sufficient size and strength to prevent settlement of pipes. Sufficient space shall be left to enable joints to be made, tested and inspected.

A.11 When pipe laying is not in progress, open ends of pipes shall be closed with properly fitted temporary wooden plugs or standard caps as approved by the Engineer.

B. Jointing

B.1 Manufacturers' instructions shall be followed regarding placement of bedding and backfilling, cleanliness of joint surfaces, the lubricant used, the correct location of components and the provision of correct gaps between ends of spigots and backs of sockets.

B.2 Flexible joints shall not be deflected beyond the maximum permissible angles given by the manufacturer and/or relevant Standard.

B.3 Patent detachable and flexible joints shall strictly comply with special instructions issued by the manufacturers of proprietary joints when laying and jointing.

B.4 Differing pipes and fitting material shall be jointed with adaptors as recommended by the pipe manufacturer.

C. Line and Gradients

C.1 In open excavations sight rails and boning rods shall be provided and correctly maintained and painted to ensure the correct alignment of pipe runs. Sight rails shall be positioned either vertically above the lines of pipes or immediately adjacent thereto. At least three sight rails shall be provided for each length of pipeline under construction to any one gradient.

C.2 In headings marks shall be provided and maintained to establish the line and level of pipelines. Marks shall be fixed in each working shaft and two further marks established in each length of heading.

D. Tolerances

D.1 For gravity sewers tolerances shall be 6 mm in level and 25 mm in line between manholes or access points unless otherwise specified or approved by the Engineer. Where pipes are to be constructed in straight lines between manholes, the length will not be accepted if a light shone from each manhole cannot be seen from adjacent manholes.

E. Floatation

E.1 Whenever water is excluded from the interior of pipes, sufficient backfill shall be placed above the pipes to prevent floatation.

E.2 In the event of any pipe floating, the pipe shall be removed and relaid to the correct line and level.

F. Pipes Built into Structures

F.1 Treatment of external surface: Outside surfaces of pipes to be built-into structures shall be thoroughly cleaned immediately before installation. Protective coatings to metal pipes shall be removed when specified. Clay and concrete pipes shall be roughened as directed on the drawings or instructed by the Engineer. Plastic pipes shall be painted with appropriate solvent cement and sprinkled with dry coarse sand whilst wet. Sheathing shall be cut away from sections to be built-in and protection shall be restored up to the external faces of structures with appropriate bituminous material after installation.

F.2 Two flexible joints or flexible patented joints shall be provided adjacent to each structure. The first joint shall be placed not more than one pipe diameter from the face of the structure and the second joint not more than the following distances away from the first:

- Pipelines not exceeding 450 mm: 2 pipe diameters
- Pipelines over 450 mm and not exceeding 1000 mm: 1.2 m
- Pipelines over 1000 mm: 1.8 m.

G. Field Testing: General

G.1 All items for testing, including pressure gauges, instruments and water shall be provided on site before testing commences

G.2 Tests shall be carried out in the presence of the Engineer.

G.3 Fittings shall be permanently anchored before testing with all joints left exposed for checking.

G.4 Test sections shall be limited to runs of not more than 500 metres.

G.5 Pressure lines shall be tested between valve chambers unless agreed otherwise by the Engineer.

G.6 Gravity sewers shall be tested in sections between manholes.

G.7 No testing shall be carried out against or through the pressure reducing valves. The setting of the pressure reducing valves shall not be changed for testing purposes.

G.8 Test plugs shall be secured at the end of the main by struts.

G.9 Testing against a closed valve shall not be permitted unless agreed to by the Engineer.

G.10 Pressure shall be applied by a manually operated test pump or, in the case of large diameter mains, by a power driven test pump, if approved by the Engineer.

G.11 The Contractor shall examine exposed joints and repair all visible leaks.

G.12 Should a test fail, the Contractor shall locate all leaks and replace or make good defective pipes or replace and make good faulty joints as necessary. The main shall then be retested.

G.13 The Contractor shall prepare and maintain test records in a format approved by the Engineer. Original copies of the test record shall be presented to the Engineer immediately after completion of the test.

G.14 Hydrostatic tests on pressure lines shall be carried out whilst pipelines are partially backfilled.

G.15 Non-pressure lines not exceeding 1000 mm diameter shall be air tested before backfilling and hydrostatically tested after backfilling.

G.16 Non-pressure lines over 1000 mm diameter shall be visually inspection tested from the inside. All joints shall be individually hydraulically tested.

G.17 Infiltration tests shall be carried out on non-pressure lines where the crowns of pipes at the highest section under testing are more than 1.2 m below the water table.

H. Hydrostatic Testing of Pressure Pipelines

H.1 For hydrostatic testing, pipes shall be slowly filled with water from the lowest point. Power-driven pumps shall not be used unless indicated on the Drawings or approved by the Engineer.

H.2 Absorbent pipes shall be filled with water and allow to stand for at least 24 hours to allow complete absorption prior to hydrostatic testing.

H.3 Entrapped air in the pipelines shall be bled before pressurizing.

H.4 Pressurizing shall to continue until the specified test pressure is reached in the lowest part of the section under test. Entrapped air shall be bled while raising the pressure.

H.5 The test pressure shall be maintained for the specified test duration with pumping stopped.

H.6 The pipeline under test shall be repressurized to the original test pressure and the respective volumes of water pumped recorded.

H.7 The pipeline will be deemed to have failed the test if:

- Visible leaks are detected, regardless of leakage being within specified limits,
- The volume of water lost during period when pumping was stopped exceeds allowable leakage levels.

H.8 Test pressures shall be 1.5 times the maximum sustained pressure, minimum 13.5 kg/cm^2 unless otherwise specified on the Drawings or agreed by the Engineer.

H.9 The test period shall be 2 hours.

H.10 The allowable leakage shall be 0.1 litre/mm diameter/km length/day/30m of applied pressure.

I. Hydrostatic Testing of Non-Pressure Pipelines

I.1 The procedure for hydrostatic testing of non-pressure pipelines shall be as described for pressure pipelines.

I.2 The test pressure shall be a 1.0 metre head of water above the pipe soffit at the highest point in the section under test and not greater than a 6 metre head of water at the lowest point. If the maximum head is exceeded then the section shall be tested in stages.

I.3 The test period shall be 30 minutes.

I.4 The allowable leakage shall be 0.02 litres/linear metre/metre diameter/30 minutes.

J. Air Testing of Pipelines

J.1 Testing shall be carried out in accordance with BS EN 752-4. The section under test shall be sealed at both ends with a leakproof plug.

J.2 Pressure shall be applied by a hand pump or other method approved by the Engineer until a pressure of 3 psi (0.2 bar) head of water is indicated on a U-tube connected to the system.

J.3 Without further pumping the pressure shall not fall to less than 1 psi (0.66 bar) after a period of 10 minutes.

J.4 If the air test is not conclusive and no leakage can be traced by an external application of soapy water to all sealing areas, then hydrostatic testing shall be carried out.

K. Infiltration Test for Gravity Pipes

K.1 Infiltration testing shall be carried out after total backfilling of the length under test.

K.2 All inlets to system shall be plugged with an airtight seal prior to testing.

K.3 Residual flow shall be measured by a method approved by the Engineer

K.4 Infiltration limits: the following limits are not to be exceeded:

- Pipelines not exceeding 700 mm: 0.02 litres/hour/100 metres/mm diameter
- Pipelines over 700 mm: 0.03 liters/hour/100 metres/mm diameter.

K.5 Tests shall be deemed to have failed if allowable infiltration water volumes are exceeded. The source of excessive infiltration shall be located by traversing lights and mirrors, inflated rubber plugs or other method approved by the Engineer and made good to the satisfaction of the Engineer. Tests shall be repeated until successful.

L. Visual Inspection Tests

L.1 Visual inspection tests shall be carried out after backfilling of the section to be tested has been completed.

L.2 The length to be visually tested at one time shall be three full-length pipes unless otherwise agreed with the Engineer.

L.3 Rubber tyred bogies which do not damage the linings of pipes and an adequate supply of electric lamps shall be used to carry out the tests.

L.4 Joints shall be checked by feelers to ensure rubber rings are correctly located.

L.5 Pipes shall be checked for visible cracks.

M. Hydraulic Individual Joint Test for Pipes Exceeding 1000 mm

Testing shall be carried out in accordance with BS 5886:1980 (ISO 4483:1979), Type 2 testing after backfilling. Joints shall be pressurized to 2 bars and repressurized to 2 bars after 2 minutes. After a further 5 minutes no pressure drop shall be observed or the test shall be deemed to have failed.

N. Deflection Tests for GRP Pipes

N.1 Deflection tests for GRP pipes shall be carried out in 3 stages as detailed below. Deflections shall be measured at the spigot ends, at mid points and at socket ends:

- **Stage 1**: at completion of primary backfill (maximum allowable deflection 0.5%).
- **Stage 2**: at final backfill (maximum allowable deflection 2.5%).
- **Stage 3**: six months after final backfill (maximum allowable deflection 4.0%).

N.2 Pipes not passing the deflection tests at stage 2 or stage 3 shall be removed and replaced.

O. Flushing and Disinfection of Water Mains

O.1 Flushing and Disinfection of Water Mains shall be carried out in accordance with AWWA C651.

O.2 The Contractor shall provide all necessary equipment, gauges, temporary connections, chlorine and water needed for flushing and disinfection.

O.3 Water mains shall be flushed and disinfected in sections as directed by the Engineer.

O.4 Washout valves and fire hydrants shall be used to drain flushing and disinfecting water.

O.5 Before commencing disinfection, mains shall be flushed until all effluent and debris has been removed and the water is clean.

O.6 Mains shall be disinfected with chlorinated water, solutions of calcium hypochlorite or sodium hypochlorite as agreed with the Engineer.

O.7 Initial dosing of the disinfecting agent shall be 40-50 ppm.

O.8 The contact period shall be 24 hours.

O.9 Residual chlorine shall be measured by orthotolidin testing. Residual chlorine shall not to be less than 5 ppm or the dosing is to be repeated as directed by the Engineer.

O.11 After disinfection has been approved by the Engineer, the network shall be flushed with potable water until the chlorine concentration in the water leaving the main is less than 1 ppm.

O.12 Bacteriological tests shall be carried out in accordance with AWWA C651, Section 9. The number of samples to be taken shall be one per 1 km of main feeder and one per 0.25 km of distribution line.

O.13 Flushing and disinfection shall be carried out after cutting into existing main: in accordance with AWWA C651, Section 11.

P. Field Protection and Coating

P.1 Polyethylene encasement for iron pipes shall be in accordance with ANSI/AWWA C105, Section 4.1 minimum thickness 200 microns and/or in accordance with the manufacturer's instructions.

P.2 Metal joints to patented detachable and flexible joints and flanged connections shall be protected with mastic compound and protective tape in accordance with the manufacturer's instructions. Minimum overlap shall be 55%. All folds and irregularities shall be pressed out.

Q. Water Supply House Connections

Q.1 Locations of tappings shall be agreed with the Engineer before starting work on construction.

Q.2 Connections shall be programmed to follow closely construction of the main network.

Q.3 Ferrule cocks shall be drilled, threaded and taped in accordance with the manufacturer's instructions.

Q4 House connections shall be excavated, installed, laid and backfilled in the same manner as the main network.

Q.5 House connections shall be tested with the main network but testing shall exclude water meters.

Q.6 Accurate records of locations of house connections to the mains network shall be maintained by the Contractor. Record details shall include the following:

- Diameter
- Length
- Location
- Position of stop valves

Q.7 The Contractor keep records in a survey log book in a format approved by the Engineer. Survey log books shall be made available for inspection by the Engineer and handed to the Employer on completion. Survey log books shall include sketches and tables and three bound copies shall be produced for the Employer.

R. Sewer House Connections

R.1 The Contractor shall agree the location and invert levels of sewer house connections with the Engineer before starting construction.

R.2 The Contractor shall programme connections to follow closely on from the construction of sewers.

R.3 Connection to sewers shall be at manholes. Connections to T or Y junctions shall only be permitted if shown on the Drawings or if approved by the Engineer.

R.4 Connections shall be laid at a minimum grade of 20 per 1000 unless otherwise approved by the Engineer.

R.5 Sewer house connections shall be installed, laid and tested using the same methods as for main sewers.

R.6 The Contractor shall maintain accurate records of locations of connections to main sewers that include the following:

- Connection number
- Type of connection
- Pipe diameter
- Downstream manhole numbers
- Distance from manholes
- Positions (left or right) when facing upstream of street sewers
- Distance from the sewer centre line to the end lateral
- Invert of street sewer
- Lateral invert at end point
- Number and type of inspection chambers
- Cover type
- Location, description and elevation of obstructions and method of protection.

R.7 The Contractor shall keep records of sewer house connections in a survey log book, made available for inspection and handed to the Employer on completion. The survey log books shall include sketches and tables in a format approved by the Engineer and three bound copies shall be provided for the Employer.

S. Cleaning and Inspection of Sewers

S.1 Sewer pipelines shall be cleared of silt and debris after backfilling of pipe trenches and completion of manholes, hatch boxes and the like but before surfaces are permanently reinstated and made ready for inspection by the Engineer.

S.2 Pipelines of 700 mm diameter and over are to be inspected from the inside and when necessary a suitable trolley is to be provided for this purpose.

S.3 Pipelines less than 700 mm diameter and larger pipelines which cannot be inspected from the inside shall be inspected by passing a cylinder of a diameter 25 mm less than the internal diameter of the pipe and a length of not less than the internal diameter of the pipe through each pipeline.

8.02.4 MEASUREMENT

A. Earthworks

Measurement and payment for trench excavation and backfilling shall be made in accordance with the provisions of Section 2.10.03 of Division 2: Earthworks.

B. Pipelines

B.1 Pressure pipes shall be paid for per linear meter measured as a straight line between the centres of consecutive coupling sections. The distance between the two centres of the couplings on both sides of any fitting or valve shall be included as pipe length. No allowance will be made for cut ends and waste. No separate payments for any in-line fitting shall be made and the costs shall be deemed to be included in the rate for pipelines.

For gravity networks, pipes shall be paid for per linear metre measured as a straight line between the inside edges of manholes plus 20 cm inside the manhole from each side. No allowance shall be made for cut ends and waste.

B.2 Rates for pipes shall include for the following:

1) Staking out, field surveying and preparation of shop drawings,
2) Pipes, couplings and fittings,
3) Appropriate fittings and/or couplings for connecting to adjacent pipe or fitting including flanged fittings connecting to socket ended pipes,
4) Additional self restrained coupling sections adjacent to bends.
5) Bolts, nuts, gaskets and the like for flanged fittings,
6) Transportation and hauling about the Site, loading, unloading and lowering materials in the trench,
7) Lubricating agent used for assembling the pipe sections,
8) Cutting, machining, chamfering, etc. of standard length pipes,
9) Assembling the pipes and couplings
10) All work involved in connecting to new or existing fittings, valves, chambers, manholes and or structures as applicable.
11) Concrete thrust blocks including associated over excavation and anchors or additional self restrained coupling sections at bends. The concrete work shall include all items required for concrete work and concrete structures,
12) Testing in accordance with the specification,
13) Ancillary works and materials,
14) Flushing, cleaning, painting, lining and coating.
15) Disinfection of water supply pipes

B.3 Rates for pipe relocation shall include for the following:

1) Staking out, field surveying and preparation of Shop Drawings.
2) Appropriate fittings and/or couplings for connecting to adjacent pipes or fittings including flanged fittings connecting to socket- ended pipes.
3) Additional self-restrained coupling sections adjacent to bends.
4) Bolts, nuts, gaskets and others for flanged fittings.
5) Transportation and hauling about the Site, loading, unloading and lowering materials in the trench.
6) Lubricating agent used for assembling the pipe sections.
7) Cutting, machining, chamfering, etc. of standard length pipes.
8) Assembling the pipes and couplings and connecting to fittings and valves, or chambers, manholes and or structures as applicable.
9) Concrete thrust blocks including associated over excavation and anchors or additional self restrained coupling sections at bends. The concrete work shall include all items required for Concrete Work and Concrete Structures.
10) Testing as per specification.
11) Ancillary works and materials.
12) Flushing, cleaning painting, lining and coating.
13) Disinfection of water supply pipes.
14) Draining, stopping and sealing ends of redundant pipes

C. House Connections

C.1 Potable water house and sewer connections shall be paid per connection installed.

C.2 Rates for house connections for water supplies shall include:

1) Supply and installation of all materials including pipes, accessories and fittings, extension spindle, water service unit box and cover.
2) Supply of stopcocks and saddles on mains (tapping collar, elbows, tees, caps, valves).
3) Excavation, bedding and backfilling, concrete works, thrust block, reinstatement
4) Installation and connection to new network and to the service box, or to the existing service connection, and testing.
5) Coordination with the Engineer in collaboration with water authority offices and bearing of all cost associated with their requirements and procedures for maintaining uninterrupted service.

C.3 Rates for sewer connections shall include:

1) Supply and installation of all materials including pipes, fittings or specials.
2) Excavation, bedding, backfilling concrete works and reinstatement.
3) Connection to adjacent inspection chamber or to existing building discharge line and to the collection network using all necessary fittings and machining required to facilitate connection.
4) Installation, testing and commissioning.

PAY ITEMS	**UNIT OF MEASUREMENT**
(8.2.1) Concrete Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.2) Ductile Iron Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.3) UPVC Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.4) Steel Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.5) GRP Pipes (*specify purpose and size*)	Linear Metre (m)
(8.2.6) Realignment of Water Supply Pipes (*type and size*)	Linear Metre (m)
(8.2.7) Realignment of Sewer Pipes (*specify type and size*)	Linear Metre (m)
(8.2.8) Water service connection	Number (No)
(8.2.8) Sewer service connection	Number (No)

SECTION 8.03 VALVES AND ACCESSORIES

8.03.1 SCOPE

The work covered in this section includes the furnishing of all materials, construction, installation and completion of valves, sluices, sprinklers, hydrants, taps and meters for water supply and drainage.

8.03.2 MATERIALS

8.03.2.1 Valves

A. Ductile Iron Gate Valves

A.1 Gate valves for pipes of size 50 mm and smaller shall be supplied in accordance with BS 5154:1991 with inside screws, solid wedges, rising stems and screwed bonnets.

A.2 Gate valves for pipes of size 65 mm and larger shall be supplied in accordance with BS 5163:2004, with inside screws, solid wedges, resilient seated for valves 350 mm and smaller and metal seated for valves 400 mm and larger, bolted bonnets, non-rising stem types, suitable for NP 16 for water supply networks.

A.3 Materials for component parts from basic or alternative materials shall be as listed in BS 5163:2004 and BS 5154:1991.

A.4 End connections for pipe sizes 50 mm and smaller shall be screwed ends in accordance with BS 21:1985.

A.5 End connections for pipe sizes 65 mm and larger shall be flanged end connection in accordance with BS EN 1092-2:1997.

A.6 End connections shall be as shown on the Drawings and/or as described in the Bill of Quantities. Plain end connections shall be machined to suit joints specified for adjoining pipes.

A.7 Valves larger than 400 mm diameter shall have spur gear drives operated by removable keys. Valves smaller than 400 mm shall be operated by handwheels.

A.8 Factory protection: casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar in accordance with to BS 4164:2002 or bitumen to BS 3416:1991. The minimum thickness of the applied coat shall be 250 microns.

B. Butterfly Valves: Ductile Iron

B.1 Butterfly valves shall be manufactured in accordance with BS EN 593:2004 double flanged with resilient seating, for horizontal use and suitable for NP 16.

B.2 Ductile iron butterfly valves shall be used for pipe sizes of 350 mm and larger.

B.3 Material for component parts shall be in accordance with BS EN 593:2004 Table 3.

B.4 End connections shall be flanged in accordance with BS EN 1092-2:1997.

B.5 The maximum shut off pressure against which valves are operated by hand wheel shall be 15 kg/cm^2.

B.6 Factory protection: Casting surfaces are to be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coatings shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coatings shall be 250 microns.

C. Check Valves

C.1 Check valves shall be manufactured in accordance with BS EN 12334:2001, swing, straight, for horizontal use and suitable for working pressure of 16 bars.

C.2 Component parts shall be manufactured from ductile iron and basic materials listed in BS EN 12334:2001 Table 5, under 'copper alloy faced' column.

C.3 Seating or facing rings shall be renewable. An arrow showing the direction of flow shall be visible from the outside and cast integral with the valve housing.

C.4 End connections shall either be flanged to BS EN 1092-2:1997 or screw ended to BS 21:1985 to suit joints specified for adjoining pipes.

C.5 Factory Protection: Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coatings shall be 200 microns.

D. Air Valves

D.1 Air Valves for Water and Irrigation Mains

D.1.1 Air valves for water and irrigation mains shall have cast iron bodies and bolted covers to BS EN 1561:1997 grade 14 minimum, rubber outlet seats, plastic or ebonite balls, forged bronze screws and guides for balls acting under pressure. Valves shall be dynamic types with no possibility of balls being drawn into orifice due to high air velocities. Valves shall be factory tested to 1-1/2 times working pressure and factory coated with coal tar or bituminous coatings to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coatings shall be 250 microns.

D.1.2 Single air valves, Type I (or air vacuum valve) for releasing or admitting air during filling or emptying of pipes or Type II (or air release valve) for automatically releasing, under pressure, accumulated air at summits of mains: Air valves larger than 50 mm are to be flanged to BS EN 1092-2:1997 and shall have nitrite rubber lined butterfly valves with nylon coated discs on stainless steel shafts operated by lever handles with indicator and locking thumb screws. Air valves 50 mm and smaller shall have B.S.P. threads with brass or gun metal male screwed stop valves. Valves shall be suitable for working pressures up to NP16.

D.1.3 Double air valves (combination air valves) shall have the large orifice area equal to or greater than the valve inlet. Valves shall be fitted with nitrite rubber lined butterfly valves with nylon coated discs on stainless steel shafts operated by lever handles with indicators and locking thumb screws. Valves shall be flanged to BS EN 1092-2:1997 and suitable for working pressures up to NP16.

E. Ball Valves

Ball valves 50 mm and under shall be full port, 2-piece construction, lever operated with bronze bodies and stems, chrome-plated brass balls, replaceable PTFE seats and packing, plastic coated steel handles, threaded end connections for steel piping and copper compression or solder end connections for copper piping.

F. Globe Valves

F.1 Globe valves shall be manufactured to ASTM A48 grade 30B with valve discs to ASTM A276 type 430, valve seats to ASTM A276 type 420 and stems to ASTM A276 type 403. Valves shall be suitable for a working pressure of 16 Bar.

F.2 Globe valves shall have non-rising stems, straight pattern with flanged connections.

F.3 Valves shall be class PN 10 and 16, cast iron with stainless steel trim.

F.4 Manually operated valves shall have hammer type handwheels and electrically operated valves shall have motor actuators.

G. Underground Stop Valves

G.1 Underground stop valves shall be manufactured in accordance with BS 5433:1976 with crutch or square heads.

G.2 Unless otherwise specified valve bodies, leads, glands, spindles and washer plate square heads shall be gunmetal to BS EN 1982:1999 - LG2, seating washers shall be vulcanized synthetic rubber to BS 3457:1973 Clause 6 and head sealing '0' rings shall be in accordance with BS EN 681.

G.3 End connections inlets and outlets of valves shall be internally threaded to BS EN ISO 228 to fit threaded specials to polyethylene pipe.

H. Float Valves

H.1 Float valves shall be globes with two operating chambers, sealed through piston discs.

H.2 Float valves shall be the mechanically compensating, controlling the flow to tanks by modulating in direct ratio to the minimum fall in water level. Control shall be through mechanically operated, three-position, four-way valves. Moving four-way valve controls in one direction shall open valves and moving levers in other direction shall close out valves. When the lever is moved to the centre, valves shall throttle into an intermediate position.

H.3 Valve positioning controls consists of float operated linkage mechanisms for remote mounting feeding water level changes back to main valves through low friction, flexible push-pull cables supplied by the same manufacturer.

H.4 Valve operating controls consists of secondary linkages with the mechanism functioning off common levers connected to both the main valve position indicator rods, control valve position indicator rods and control valve operating levers. Minute changes in water level shall be transmitted through push-pull cables to three-position, four-way control valves.

H.5 Valves shall be constructed with cast iron bodies to ASTM A 126, bronze valve trim and valve operating mechanisms to ASTM B62 and all stainless steel valve floats and pilots.
Valves shall be protected with an internal coating of epoxy to a thickness of 120 microns and external coating of epoxy and nickel plating to a thickness of 120 microns.

I. Air Valves for Pressurised Sewer Mains

I.1. Valves shall be manufactured with cast iron bodies, covers and baffles to BS EN 1561, Grade 14, stainless steel float and float guide, Buna-N seats or needles and nylon internal linkages. Air valves shall have long float stems and bodies to keep valve operating mechanisms free from contact with sewage by maintaining an air gap between the mechanisms and the waste media. Floats shall hang freely in the centre of valve bodies with 12 mm clearance all around to prevent large solids getting above the float. Valves shall be fitted with blow off valves, quick disconnect couplings and minimum 2.0 m of hose to permit backflushing without dismantling valves. Valves shall be factory tested to 1.5 times working pressure and factory coated with coal tar bituminous coatings to BS 4164:2002 or BS 3416:1991 respectively. The minimum thickness of coating shall be 250 microns.

I.2. Single air valves shall be specified as Type I (air vacuum valve) for releasing or admitting air during filling or emptying of pipes or Type II (air release valve) for automatically releasing, under pressure, accumulated air at summits of mains. Air valves 50 mm and smaller shall have screwed inlet to B.S.P. thread with gunmetal male screwed stop valve. Air valves larger than 50 mm shall be flanged to BS EN 1092 and have nitrite rubber lined butterfly valves with nylon coated discs on stainless steel shafts operated by lever handles with indicators and locking thumb screws. Valves shall be suitable for working pressures of up to NP10.

I.3. Double air valves (or combination air valves) shall be assemblies of an air vacuum and an air release valve. Valves shall be suitable for working pressures up to NP16.

J. Sluice Gates

J.1 Sluice gates shall be manufactured in accordance with AWWA C501, with rising stems, flat backs for bolting to wall, suitable for 6 metre seating pressure and 4 metre off-seating pressure, standard conventional closures and rectangular or circular apertures.

J.2 Unless otherwise specified on the Drawings slice gates shall be manufactured from any materials listed in Section 2 of AWWA C501 except materials identified as being subject to de-zincification or de-aluminumization.

J.3 Sluice gates shall be operated by floor pillars with gear boxes. The maximum operating head from the water surface to the gate centreline shall be 6 metres.

J.4 A leakage test to meet the requirements of Section 6.3 of AWWA C501 shall be carried out on all sluice gates.

J.5 Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1999 respectively. The minimum coating thickness of coat shall be 250 microns.

K. Flap Valves

K.1 Flap valves shall be flange mounted and designed for use on end closures to prevent the entrance of backwater. The seating plane shall have a 10 degree inclination.

K.2 Flap valves shall be manufactured with cast iron bodies and covers, bronze seat faces, bronze hinge pins and spring pins, cast iron follow rings and plated steel ring draw bolts. Materials subject to de-zincification or de-aluminumization shall not be used.

K.3 If end connections are specified or proposed as flange mounted, flanges shall be manufactured in accordance with BS EN 1092.

K.4 Casting surfaces shall be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coatings shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3416:1999 respectively. The minimum coating thickness shall be 250 microns.

L. Penstocks

L.1 Penstock doors, wedge support beams, frames, guides, frame extensions, headstocks and bridge pieces shall be cast iron of minimum grade 220 to BS EN 1561:1997. Doors and frames shall be fitted with renewable seatings of zinc free bronze.

L.2 Spindles shall be manufactured from stainless steel 431S29 (BS 970) or similar approved material.

L.3 Extension spindles shall be adequately sized to prevent buckling and shall be attached to the valve/penstock stem by a suitable adaptor incorporating two muff couplings, scarf lap jointed and pinned with at least two coupling joints included. Universal joints and waterproof sleeves shall be provided where specified. Extension spindles shall be manufactured from 080M40 (BS 970) steel. Intermediate bearing supports or guide brackets of cast iron, with slotted holes for site adjustment, shall be fitted to long shafts where necessary. Bearings shall be of PTFE unless otherwise agreed with the Engineer.

L.4 Penstock and valve pedestals shall be of cast iron or heavy duty, welded, mild steel construction. The base and top of the pedestals shall be machined normal to the axis of the drive shaft.

L.5 Where necessary, support guide bushes shall be fitted at the base of the pedestal.

L.6 The pedestal height shall be such that the handwheel is approximately 1 metre above the operation floor level.

L.7 Clear polycarbonate covers shall be provided for all rising spindles to fully enclose them when in the fully raised position.

L.8 All penstocks shall be designed and installed so that the maximum working pressure acts in a seating direction on the gate.

L.9 Gates and frames shall be sufficiently rigid to withstand twice the maximum working pressure and any eccentric pressures created by the tightening of the anchor bolts during installation. All penstock frames shall have a spigot back.

L.10 The frame shall be designed to ensure that the gate is supported over not less than two thirds of its depth when the gate is fully raised.

L.11 Penstocks shall be of the rising spindle type unless otherwise specified. The spindles shall be of adequate size to avoid buckling under load.

L.12 All spindle nuts shall be self aligning and their length shall be not less than twice the spindle diameter.

L.13 The top part of the penstock frame shall be sufficiently robust and substantial to prevent the frames bowing and if necessary, additional holding down bolts shall be fitted. The penstocks shall be fitted with matching wedges on doors and guides, the wedges shall be fitted with renewable seatings of zinc free bronze. Under no circumstances shall wedges be fitted to the bottom or lower sections of the penstock doors. The wedges shall be adjustable with stainless steel adjusting screws and shall be readily removable.

L.14 On rectangular penstocks the inverts shall be flush with renewable synthetic rubber seals on the bottom of the doors. The rubber shall be suitable for the application and of a type approved by the Engineer.

L.15 The doors shall have lifting eyes cast in, or eye bolts of sufficient size to permit the lifting of the door against the seating pressure.

L.16 Where extended spindles installations require to be operated at an elevated floor level, spindle guides or guide brackets shall be provided close to the floor level.

L.17 Where penstocks are required to be operated by tee keys, spindle caps shall be fitted. The caps shall be drilled and each provided with nuts and bolts for securing to the spindle which shall also be drilled. Where caps are fitted they shall be supplied complete with operating tee keys.

L.18 All penstocks shall be provided with headstocks except where the handwheels can be mounted on the penstock frames. For penstocks of 300 mm ND. (square or circular) and above and for all motorized and actuator operated penstocks, unless otherwise stated, thrust tubes shall be provided between the penstocks frame and the headstock, in order to absorb the operating thrust in both directions. Thrust tubes shall incorporate all necessary fixing brackets and spindle quid plates.

L.19 Headstocks and foot brackets shall be provided for non-rising spindle penstocks unless otherwise detailed in the Drawings. Guide brackets shall be provided where necessary. Non-rising spindles shall be fitted with thrust collars and arranged so as to transmit the thrust arising from operation of the penstocks directly to the penstock frames. Where headstocks are required on non-ring spindle installations they shall incorporate a penstock position indicator.

8.03.2.2 Irrigation Works

A. Electric Remote Control Valves

A.1 Electric remote control valves shall be normally closed 24 V AC 50/60 cycle solenoid actuated globes of a balanced pressure diaphragm design. The valve operating pressure range shall be between 1.5 and 14 bars.

A.2 Valve bodies and bonnets shall be constructed of heavy-duty glass-filled UV-resistant nylon and have stainless steel studs and flange nuts. The diaphragm shall be manufactured from nylon reinforced rubber.

A.3 The valves shall have manual open/close controls (internal bleed) for manual operation of valves without electrically energizing the solenoids.

A.4 The valves shall have brass flow control stems for accurate manual regulation and/or shut off of outlet flows.

A.5 All internal valve parts shall be removable through the tops of valves without disturbing the valve installation.

B. Electric Remote Control Valves with Pressure Regulation

B.1 Electric remote control valves shall have pressure regulating modules capable of regulating outlet pressures of between 1 and 7 bar.

B.2 Modules shall have adjusting screws for setting pressures and Schrader valve connections for monitoring pressure. Pressures shall be adjustable from the pressure regulating modules when valves are manually bled.

C. Pop-Up Spray Sprinkler

C.1 Pop up spray sprinklers shall be fixed, non-rotating spray or stream spray types adaptable for full circle, part circle or strip wetting patterns and suitable for installation on pop-up mechanisms. Spray heads shall have built in check valves and pressure regulated stems.

C.2 The sprinkler body, stem, nozzle, and screen shall be constructed of heavy duty, ultra-violet resistant plastic with a heavy-duty stainless steel retract spring.

C.3 Spray heads shall retract flush with the finished ground level when not in operation. When spraying, the net pop-up height shall be 150 mm from the finished ground level.

C.4 Pop up spray sprinklers shall meet the requirements of discharge and spray radius as specified on the Drawings for the given nozzle pressure. Each sprinkler shall have a matched precipitation rate nozzle with an adjusting screw capable of regulating the radius of flow.

C.5 The Contractor shall provide test results carried out at the factory substantiating required performance (discharge and radius of throw at prescribed operating pressure and height above ground) and giving the actual precipitation rate and its uniformity as obtained for uniformity test carried out using catch cans.

D. Pop-Up Rotor Sprinkler

D.1 Full or part circle pop-up rotor sprinkler shall have a single nozzle. The part circle sprinkler shall have adjustable arc coverage from 25° to 360°. Each sprinkler shall have a built in check valve and pressure regulated stem.

D.2 Each sprinkler body, stem, nozzle, and screen shall be constructed of heavy duty, ultra-violet resistant plastic, with a heavy duty stainless steel retract spring.

D.3 Sprinkler heads shall retract flush with the finished ground level when not in operation. When operating, the net pop-up height shall be 100 mm above finished ground level.

D.4 Sprinklers shall meet the requirements for discharge, radius and rotation angle as specified on the Drawings for the given nozzle pressure. The sprinkler shall have a matched precipitation rate nozzle, with an adjusting screw capable of regulating the radius and the flow.

D.5 The Contractor shall provide test results carried out at the factory substantiating the required performance (discharge and radius of throw at prescribed operating pressure and height above ground) and giving actual precipitation rates and uniformity as carried out using catch cans.

E. Bubblers

E.1 Bubblers shall be of the pressure compensating type with full circle umbrellas or trickle discharge and inlet screens.

E.2 Bubblers shall be manufactured from durable ultraviolet- resistant plastic.

E.3 Bubblers shall operate at a constant flow discharge over a pressure range as specified on the Drawings.

F. Emitters

F.1 Emitters shall be the pressure compensating type with single outlets.

F.2 Emitters shall have self piercing inlet barbs constructed of durable ultraviolet- resistant plastic.

F.3 Each emitter shall have a self flushing action to minimize clogging and shall operate at a constant flow discharge over a pressure range as specified on the Drawings.

G Quick Coupling Valves

G.1 Quick coupling valves shall be the two piece type.

G.2 The valve body shall be constructed of heavy cast brass.

G.3 Covers shall be manufactured from durable, self-sealing rubber.

G.4 Valves shall be opened and closed by brass keys supplied by the manufacturer having 25 mm male top pipe threads at inlets and 19 mm female top pipe threads at outlets. Valve throats shall have keyways with indented positions for regulating water flow. Operating keys shall be supplied at the rate of 1 per 5 couplings installed or fraction thereof.

H. Backflow Preventers

H.1 Backflow preventers shall be of the reduced pressure type and be installed in the locations shown on the Drawings.

H.2 Backflow preventers shall meet the performance requirements of AWWA C 511.

H.3 Backflow preventers up to 75 mm in size shall have machined cast bronze body construction and up to 150 mm in size shall have a cast iron body construction and with epoxy coated stainless steel and/or brass internal parts, stainless steel flange bolts and durable, tight-seating rubber check valve assemblies.

H.4 Backflow preventers shall be suitable for supply pressures of up to 1.2 MN/ m^2 and for water temperatures of up to 44 ^{O}C. The operating range for flow and pressure loss shall be as shown on the Drawings.

H.5 The backflow preventer assembly shall consist of a pressure differential relief valve located between two positive seating check valves. The relief valve shall contain a separate portal for venting and water discharge, when the valve is fully open.

H.6 The backflow assembly shall include 2 gate valves for isolating units and 3 test cocks for testing the device to ensure proper operation.

H.7 Backflow preventers shall be designed for inline servicing.

I. Isolating Valve

I.1 Gate valves shall have brass bodies and bonnets. Valve stems and seats shall be removable from the valve body without disconnecting the body from piping network. Valves shall be PN 20 and have female threaded sockets.

J. Air and Vacuum Relief Valves

J.1 The air and vacuum relief valves shall be of the orifice type and non-corrosive construction. The valve shall be rated at 10 bar working pressure. The floating balls shall be of vulcanized rubber and shall withstand a temperature of 60°C. Air vacuum assemblies shall be installed at high points to allow air and vacuums to be expelled.

K. Inline Filter

K.1 The in-line Wye filter shall be constructed specifically for low flow irrigation applications. The filter body shall be constructed of heavy duty glass filled UV resistant nylon material providing a pressure rating of not less than 10 Bar. The filter element shall be constructed of a durable polyester fabric attached to a polypropylene frame

K.2 The standard 200 mesh screen shall be serviceable for cleaning purposes by unscrewing the cap from the body and removing the filter element. Colour coded replaceable filter elements of 150 mesh (blue) and 200 mesh (white) shall be available from the manufacturer of the inline filter. The body shall have a 20 or 25 mm female threaded inlet and outlet. The design shall be of a compact "Y" body and cap configuration.

L. Pumps and Pumping Stations

L.1 Submersible Motor-Pump Set

L.1.1 Operation

Horizontal submersible pumps shall be located in reservoirs. The operation of this pump shall be automatically controlled by the system controller during irrigation. They shall be started daily at a predefined time and shall be stopped when the water level in the reservoir reaches the water sensor levels.

L.1.2 Electric Motor

L.1.2.1 Type

Electric motors for submersible pumps shall be supplied in accordance with the following:

- Wet type submersible motor
- 3 phase – 50Hz – 380V – Asynchronous
- Horizontal axis – IP68 Class Protection

L.1.2.2 Power

The motor power unit shall exceed by 20% the required power taking into consideration the losses due to cables and wiring.

L.1.2.3 Maximum Rotation Speed

The maximum rotation speed of pump motors shall be 3000 rpm.

L.1.2.4 Output and Output Factor

When the motor's power is at 75 % of the nominal power, the output shall be at least 80% and the output factor at least 0.8.

L.1.2.5 Mechanical Couples

The Contractor shall submit details of the various couples (nominal couple, starting couple, maximum couple and other data as applicable) selected by both the pump and the motor manufacturer to the Engineer for approval.

L.1.2.6 Technical Specifications for Manufacturers

Electric motors shall be manufactured in accordance with the following:

- Wet stator windings with special PVC insulated copper conductors.
- Temperature rise limited to class B.
- Insulation: Minimum Class F
- Transmission shaft made from stainless steel with a 12% minimum chrome content.
- Protection degree IP68
- Bearings shall be the self lubricating type, designed to ensure proper alignment of the rotor and shaft.
- Construction standards: NFC 51-165 & NFC 51-104.
- Motors shall be fitted with expansion diaphragms.
- Coupling: rigid sleeve coupling.
- Cables in continuous lengths from the inside motor connections to motor control panels.
- Paint finish: seawater resistant synthetic resin.
- Submersible pump sets shall be fitted with cooling shrouds.

L.1.3 Pumps

L.1.3.1 Type

Pumps shall be centrifugal or helicoid centrifugal multiple stages, for horizontal installation and handling clean, cold water.

L.1.3.2 Rotation Speed

The pump rotation speed shall be the same as for the electric motor rotation speed and at 3000 turn/min as a maximum.

L.1.3.3 Output

Pump outputs shall not be less than 70% in normal conditions of use.

L.1.3.4 Working Temperature

Pumps shall be capable of operating with a water temperature of between 10° C and 25° C

L.1.3.5 Technical Specifications for Manufacturers

Pumps shall be manufactured in accordance with the following

- Turbines shall be the closed or half closed type, made of zinc- free bronze.
- Pump bodies shall be manufactured from bronze or cast iron, internally enamelled,
- The manufacturer shall specify the minimum head loss through friction for each pump.
- Transmission shafts shall be made of stainless steel with a high percentage of chrome (13% minimum).
- Bronze bearings shall be used.
- Lubrication shall occur with water circulating across the pump.
- Strainers shall be made of bronze or stainless steel.
- The pumps shall be coated with seawater resistant synthetic resin.
- Pumps shall be manufactured in accordance with BS EN 733:1995

L.1.4 Motor and Pump Assembly

L.1.4.1 The assembly between the electric motor and the pump shall follow the manufacturer's instructions. Submersible pump sets shall be equipped with non-return valves, fitted inside the pumps.

L.2 Borehole Pumps

L.2.1 Rising Columns

L.2.1.1 Borehole pump rising columns shall be manufactured from seamless steel and provided in section lengths not exceeding 3 meters with flanged joints or screwed couplings according to API5L grade B or equivalent. Rising columns shall allow for small deviations in borehole verticality. Cables and water level dip tubing shall be securely fixed to the rising column by straps or bands at approximately 2 metre intervals.

L.2.1.2 Rising columns shall be sufficient to take the stresses generated by the hanging weight of the pump, motor and rising column, the stresses produced by the water pressure together with any dynamic stresses which may occur under any circumstances including valve closure. Rising columns shall be protected at the factory both internally and externally against corrosion using a non toxic epoxy resin coating (300 μm minimum thickness) suitable for use with potable water.

L.2.2 Borehole Pump Headworks

L.2.2.1 A fabricated steel discharge head piece shall be provided at the top of each borehole to support the complete rising column and electro-submersible pumpset assembly, complete with lifting eye bolts. The discharge head piece shall comprise a heavy duty sealing plate arranged for bolting to the borehole outer casing flange, and a 90° discharge bend arranged for flanged connection to both rising column and horizontal surface pipework. Lifting eyes shall be provided in the sealing plate. A flange shall be provided and welded by the Contractor to the top of the borehole outer casing. The flange shall be suitably drilled to accommodate the discharge head piece sealing plate bolts. Holes shall be provided in the sealing plate to accommodate an air vent pipe, motor and control cables, water level dip tubing, etc. and shall include adequate sealing arrangements to protect against borehole contamination.

L.2.2.2 A 25mm diameter screwed removable plug with electrical contact tape shall be provided over the dip tubing for water level measurement. A stainless steel air vent pipe shall be fitted to the discharge head sealing plate, terminating in an insect-proof screen and arranged to prevent entry of rain or surface water.

L.2.3 Electric Panelboards

L.2.3.1 Panelboards shall be the dead-front type, enclosed metal, floor mounted (pedestal type), free standing, 600V class of service switchboards.

L.2.3.2 Panelboards shall be rigidly framed and bolted, with electro-galvanized sheet steel enclosures, minimum thickness 2 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating in a colour approved by the Engineer.

L.2.3.3 Switchgear shall be vermin, dust and rodent proof, IP65 suitable for exposed outdoor installation.

L.2.3.4 Control and measuring instruments shall be installed on removable cover plates inside the panelboard.

L.2.3.5 Schematic and wiring diagram shall be provided, suitably located within the panelboard.

L.2.3.6 The panelboard shall be provided with 1 socket outlet, which shall be installed to facilitate connection of portable tools.

L.2.3.7 The panelboard shall be fitted with a demountable undrilled metal gland plate positioned at a low level but with adequate space for termination of cables, conduits, etc. The gland plates shall be efficiently earthed to the panel earthing system by a separate earthing conductor. The base of the panel shall be provided with removable plates of the split type to seal the cable/conduit entry cut-outs. The plates shall be positioned directly below the gland and base plate shall be of non-ferrous material. Panelboards shall be suitable for mounting on concrete plinths.

L.2.3.8 All foundation holes shall be at least 75 mm from any outside edge of the panel and at least 75 mm from any concrete edge to avoid break-out when tightening bolts.

L.2.3.9 Where multiple compartments are used, each compartment shall be provided with a full width access door.

L.2.3.10 All doors and covers shall have returned edges for rigidity and incorporate dust seals of flexible material secured in channel rebates. Covers exceeding 0.5m² in area shall be provided with a supporting lip within the lower edge or have lift-off hinges. All doors shall be supported on strong hinges of non-corrodible material and shall be secured by adjustable quarter-turn cams, operated by small tee handles incorporating key operated barrel locking facilities or flush locks with drive key inserts. Covers shall be secured by similar fastenings or captive bolts.

L.2.3.11 All additional fittings such as handles, hinge brackets and locks shall be to a black finish, polyamide moulding or epoxy coated metal.

L.2.4 Terminals

L.2.4.1 Terminal blocks shall be provided for the connection of cables.

L.2.4.2 Terminal blocks shall be arranged so that both terminals and wiring ends are readily accessible and have separate terminals provided for incoming and outgoing wires, together with insulated barriers between adjacent connections and transparent insulated covers. Blocks accommodated on common mounting rails shall have a foot designed to ensure a secure fit to the rail. Foot springs shall be of stainless steel and have a locking device fitted to prevent accidental release of the block.

L.2.4.3 Each terminal shall be labelled to correspond with the diagram of connections and terminal identification labels shall be attached to the fixed portion of the terminal blocks only. Terminals for intrinsically safe circuits shall be clearly segregated and coloured blue.

L.2.4.4 Terminals which may be live when the equipment is isolated from the mains supply shall be adequately shielded from accidental contact and be clearly identified and inscribed accordingly.

L.2.4.5 All terminal boards and terminal blocks shall provide a positive mechanical clamp type connection. Pinch screw type terminals shall not be used. Terminals for the connection of all external cabling shall be situated at least 100 mm from their respective gland plates or further if the cable size requires a greater distance for dressing.

L.2.5 Circuit Breakers

L.2.5.1 Moulded Case Circuit Breakers

Moulded case circuit breakers shall be of the quick make, quick break and trip-free type complying with BS EN 60947-4-1:2001 and shall have adjustable thermal magnetic trip units on each pole or an electronic trip unit.

L.2.5.2 Thermal-Magnetic Motor Circuit Breakers

Thermal-magnetic circuit breakers shall be of the quick make, quick break trip type complying with BS EN 60934:2001 and BS EN 60947-4-1:2001 standards and shall be complete with the following:

- An adjustable thermal overload protection with automatic temperature compensation between -20° C and +60° C for open mounting and -20° C and +40° C for closed mounting.
- An instantaneous protection against short-circuit with fixed threshold 13 times the rated current.
- A minimum of three auxiliary switches that indicate pole position and a minimum of one auxiliary switch for tripping.
- A shunt trip release for remote tripping.
- A counter that indicates the number of open/close or tripping operations of the circuit breaker for maintenance purposes.
- A visual indication of open/close/tripped condition.
- Circuit breakers shall be padlockable in the "OFF" position.

L.2.5.3 Miniature Circuit Breakers

Miniature circuit breakers shall be of the quick make, quick break and trip-free type complying with BS EN 60898:1991 Circuit breakers shall be complete with thermal/magnetic or magnetic/hydraulic releases. Multi-pole breakers shall have a common trip bar and trip elements on each pole to ensure that any abnormal condition on any pole will cause all poles to open simultaneously. Visual indications of open, close and trip conditions shall be provided. Circuit breakers shall be padlockable in the "OFF" position where specified.

L.2.5.4 Residual Current Circuit Breakers

Residual current circuit breakers shall be arranged to isolate each live conductor simultaneously within 30 milliseconds if the residual leakage current through the device exceeds 30mA. They shall be housed separately or incorporated into other composite enclosures, with provision for testing the tripping operation under earth leakage conditions by means of built-in resistors and push buttons and require manual resetting.

L.2.6 Motor Starters

L.2.6.1 General

Motor starters shall be housed in damp-proof and dustproof cubicles.

Each starter shall contain all the necessary equipment to control the circuit load and isolate it from the supply in the event of a fault and shall be equipped to comply with the following general requirements unless otherwise specified under the relevant starter duties.

For starting LV Motors direct on line, the starter shall be rated for intermittent duty class 0.3 (up to 30 operating cycles/hour) and utilization category AC3 in accordance with BS EN 60947:2001, or as otherwise specified.

The starters shall comply with BS EN 60947-4-1:2001 (Motor starters for voltages up to and including 1000V AC). The motor starter shall be of a rating to carry the full load current of its rated duty at its most severe load conditions. All starters shall be capable of carrying out at least the number of starts per hour at 100% full load torque.

Motor starter control circuitry shall be arranged to suit the motor drive.

Unless otherwise specified, 3-phase, 380V motors shall be provided with Direct-On-Line starters up to and including 5 KW rating.

The Contractor shall ensure adequate rating for operating under the relevant climatic conditions and demonstrate this to the Engineer’s satisfaction.

The motor starter shall be of sufficient rating to carry the full load current of its rated duty at its most severe load conditions. Panel control circuits shall operate at 110/220 VAC single phase.

L.2.6.2 Contactors

Power contactors shall be to BS EN 60947-4-1:2001 and shall have the following characteristics:

- Rated insulation voltage: > 1000 V
- Rated Operational Voltage : 1000 V
- Rated breaking capacity : 10 times the rated current.
- Electrical life at rated current and 380 V : > 1 million cycles.

All contactors shall be of the air-break electro-magnetically held-on type. All contact pieces shall be readily replaceable and the necessary auxiliary contacts for control, indication and alarm shall be mounted in accessible positions and arranged in the same sequence on each contactor.

L.2.6.3 Protection

Each starter shall be provided with an adjustable motor over-load and single phase protection device suitable for the motor load and have adjustable trip and reset delays provided, together with manual local and remote resetting facilities. Ambient temperature compensation shall be provided where relevant. Other protection features shall be as specified relevant to the particular drive.

Protection devices shall be arranged to trip the load and initiate the fault indications specified and accept normal switching of load.

Where starters are fed directly from busbars or other systems having a high prospective fault level, suitably rated fuses or other means shall be provided within the starter to limit the fault let through to a value within the rating of the starter components. Protective overload devices shall be arranged to ensure that any such fault is cleared by such fuses and provide Type '2' coordinated protection to BS EN 60947-4-1:2001.

L.2.6.4 Star Delta Starters

Star Delta starters shall be of the closed transition "Wauchope" type, having starting resistors, mechanically and electrically interlocked Star and Delta contactors plus a timing relay in addition to DOL starter requirements, all rated for up to 10 starts per hour.

L.2.6.5 Auto-Transformer Starters

Auto transformer starters shall be of the closed transition "Korndorffer" type, having suitably rated mechanically and electrically interlocked "start" and "run" contactors plus a timing relay in addition to DOL starter requirements.

The auto transformer shall be oversized, Class H, air cooled with tappings provided at 50%, 65% and 80% of line voltage and be suitably rated for up to 10 starts per hour. The transformer shall be contained within the starter panel or may be installed in a separate enclosure.

Contactors shall be of the same type and rating. The current rating of the contactors shall be chosen 10% higher than required by the driving motor in utilization category AC3.

L.2.6.6 Motor Managers

Each motor shall be a self- monitoring unit with the following operating features:

- Select and change operating parameters.
- Select and modify setting values.
- Display values and modifications.
- Indicate faults.
- Test, e.g. verify the unit operation.
- Reset: Enable the unit after a trip.

Technical data:

- Operating temperature : -5°C to 60°C
- Storage temperature: -40°C to 60°C
- Climatic sensitivity: as per BS EN 60068-2-1:1993 and BS EN 60068-2-30:2005.
- Degree of protection: IP65
- Resistance to vibration: as per BS EN 60068-2-6:1995.
- Resistance to shock: as per BS EN 60068-2-27:1987.
- Noise emission and noise proof in accordance with EMC Standard.
- Power supply module shall be self-protected against short circuits.
- Data shall be retained in case of voltage supply failure.
- Fail-safe operation.
- Output relays (contacts) galvanically separated.

Protective functions:

- Thermal overload.
- Asymmetry.
- Overload.
- Rotor stalling during running and starting period.
- Underload
- Earth fault.
- Long starting (monitoring of starting time).
- Limited starts per hour.
- Short circuit.
- Thermistor (PTC) input.
- Phase sequence.
- Phase failure.
- Pt 100 input.

In addition to the protection brought by the motor manager, the submersible pumps shall be protected against overpressure and low water level (in the reservoir or in the borehole).

L.2.6.7 Control Circuits

The submersible pump in the reservoir shall be controlled by the pumping start relays of the sprinkler control system.

The submersible pump in the borehole shall be controlled by the water level inside the reservoir. It shall be stopped when the reservoir is full.

An 'AUTO/MANUAL' selector switch shall be provided to ensure manual control when needed.

All control circuits shall operate at not more than 110V and be derived from a double- wound, screen earthed isolation transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from one phase to neutral if available.

Fuses shall be provided on each primary and secondary supply and be clearly labelled and segregated. A link shall be fitted in the neutral/earth connection.

The control circuit and the mains supply must be isolated before opening the cubicle door but provision shall be made to re-energize the control circuit when the mains supply to the cubicle is isolated so that the operation of the control gear may be inspected without energizing the motor. The control circuit Normal/Test switch shall

be mounted within the cubicle and arranged so that it is not possible to close the door with the switch in the 'Test' position.

Control selector switches fitted to the front of starters shall have matching operating handles which are clearly shaped to show the selected position. Specified function switches shall have key operated barrel locking devices in the handle, or be key-operated alone, with the key removable in each lockable position.

All fault conditions relevant to each mode of operation shall stop the drive and prevent it re-starting until the particular fault is cleared and individually reset; lock-out relays and a reset button shall be provided for any self-resetting devices such as excess torque switches etc.

Specified fault conditions shall be identified by separate indications on the starter. Volt-free contacts shall be provided and wired to terminals in each starter unit for remote signalling of all status indications specified. Minimum status indications shall be Auto Available/Unavailable and Running/Fault.

"Hours-run" meters shall be of the non-resettable cyclometer type indicator having a flush fascia and driven by a synchronous motor connected to show the hours (up to 99,999.9) run by the main motor. They shall incorporate a visible indication of operation but need not necessarily be of the same bezel size as the instruments.

All starters for motors of 3 kW and above shall have ammeters. Local 'running' indicator lamps shall be provided for loads less than 3 kW.

Control circuits shall be protected by appropriate fuses or circuit breakers.

L.2.7 Power Cables

L.2.7.1 Single Core PVC Insulated Cables

Unless otherwise specified, single conductor cables for wiring in conduit shall have annealed copper conductors, generally with concentric strands and insulated with flame retardant, moisture and heat resistant PVC/E to IEC 60227, suitable for wet locations and for conductor temperatures of 85 °C. Wires and cables are to be 450/750 V grade.

L.2.7.2 Multi-Core PVC Insulated Cables (0.6/1 kV)

Multi- core PVC insulated cables shall have annealed, copper conductors, insulated with PVC/E to IEC 60227, flame retardant, moisture and heat resistant, suitable for wet locations and conductor temperatures of 85 °C, laid up, bedded with suitable filler and sheathed with PVC. Armoured cables shall have single layers of galvanized steel wire armour with PVC oversheathes. Cables shall comply with IEC 60502 and IEC 60811.

L.2.7.3 Single Core XLPE Insulated Feeder Cables (0.6/1 kV)

Single-core circular stranded annealed copper conductors shall be insulated with flame retardant, moisture and heat resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 °C and PVC over-sheaths. Armoured cables shall have taped bedding, single wire aluminium armour and PVC oversheathes.

L.2.7.4 Multi-Core XLPE Insulated Feeder Cables (0.6/1 kV)

Single core annealed copper conductors, XLPE insulated, for conductor temperatures of 90 °C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and PVC oversheathed, colour black. Armoured cables shall have a single layer of galvanized steel wire applied helically over extruded PVC bedding (which may be an integral part of filling) and oversheathed with PVC, coloured black. PVC oversheathes shall be type ST2 to IEC 60502.

L.2.8 Earthing Systems & Surge Protection

L.2.8.1 General

The earthing system shall consist of one or several rods. The resistance of the earthing system shall not exceed 5 Ohms. The Contractor shall install a sufficient number of rods to achieve this resistance value.

Each earthing rod shall consist of a copper-clad steel core, with a minimum diameter of 18 mm and a length of 2.5 m. The heads of the grounding rods shall be buried 500mm deep in the ground. A concrete manhole having a 500mm side shall be prepared for each earth terminal in order to facilitate maintenance operations and later reinforcement works utilizing additional elements if required to increase the earthing installation.

The manhole shall have a coloured plastic cover allowing permanent access.

The head of each earthing terminal shall be fitted with a sectioning bar allowing the isolation of this earthing element from the installation and the measurement of the ground resistance.

The connection of earthing cables to the earthing system shall be by sockets ensuring a good contact.

L.2.8.2 Earthing Conductors

Sections of earthing conductors for the various panel terminal and power supply circuits shall be as for the phase conductor of the corresponding circuits and not less than 2.5 mm^2.

Connections shall be carried out by permanent welding or screw clamping.

All insulated earthing conductors shall be yellow-green. This colour shall not be used for any other part of the installation.

L.2.8.3 Protection Against Power Surges

Electrical and electronic equipment shall be protected against surges or transients generated by switching operations, electrostatic discharges and induction by lightning and overvoltage arresters.

Compatible overvoltage devices for 'line-side' protection, that includes basic, medium level and detailed protection, shall be installed.

Overvoltage devices shall be installed in accordance with BS EN 60099 and to the manufacturer's recommendations and shall have the following characteristics:

- Modular design
- Visual fault indication
- Remote signalling module
- Replacement of active module (varistor) without interrupting the power supply
- Negligible leakage current
- High discharge capacity
- No follow current when the surge voltage has died down
- Short response time

M. Fire Hydrants

M.1 Post Type Hydrants

M.1.1 Post type fire hydrants shall be dry barrel, manufactured in accordance with AWWA C502 and suitable for a maximum working pressure of 16 Bar. Hydrant sizes shall be 100 mm for 2 outlets and 150 mm for 3 outlets. Stand posts shall be supplied with two 65 mm nozzle hoses for 100 mm hydrants and two nozzle hoses 65 mm and 100 mm pumpers for 150 mm hydrants. Hydrants shall be complete with duckfeet and isolating gate valves. Hydrants shall be of the tilt-off version and shall be provided with intermediate seal bushes to guarantee leak tightness in case of breakage due to traffic accidents.

M.1.2 Post type fire hydrants shall be manufactured from any materials stipulated in AWWA C502 except for materials subject to de-zincification or de-aluminumization.

M.1.3 End connections shall be as shown on the Drawings. Flanged connections, if used, shall be to BS EN 1092-2:1997.

M.1.4 The colour of hydrants and threads of screwed outlet nozzles shall be in accordance with local fire authority requirements.

M.1.5 The direction of rotation of operating nuts to open hydrant shall be counter-clockwise. Operating keys shall be provided at the rate of 1 per 5 hydrants installed or fraction thereof.

M.2 Underground Type Hydrants

M.2. 1 Post type fire hydrants shall the screw-down type manufactured in accordance with BS EN 14339:2005.

M.2. 2 Flange connections shall be in accordance with BS EN 1092-2:1997.

M.2. 3 Threads of screwed outlets or mouthpieces shall suit local fire authority requirements.

M.2. 4 Covers and frames shall cast iron to BS EN 124:1994, medium type.

M.2. 5 Covers shall be opened by keys. The direction of opening shall be counter-clockwise. Operating keys are to be provided at the rate of 1 per 5 hydrants installed or fraction thereof.

N. Service Connections

N.1 Ferrule Cocks

N.1. 1 Ferrule cocks shall be the plug, quarter-turn closing type.

N.1. 2 Ferrule cocks shall be manufactured from cast gunmetal to BS EN 1982:1999 1400 - LG2-C or cast iron to BS EN 1561:1997 grade 12 with a copper alloy plug.

N.1. 3 End connections shall have one end screwed male fitted directly to a pipe saddle and the other end to fit push fit joints to polyethylene pipes or as shown on the Drawings.

N.1. 4 Ferrule cocks shall be suitable for mains network pressure.

N.1. 5 Surface boxes, valve caps, extension spindles and protection tubes and protective covers shall be of the same material as specified for gate valves with dimensions and constructional details as shown on the Drawings and/or to the manufacturer's standards.

N.2 Underground Stop Valves

N.2.1 Underground stop valves shall be manufactured in accordance with BS 5433: 1976 with crutch or square heads.

N.2.2 Unless otherwise shown on the drawings or specified by the Engineer, bodies, leads, glands, spindles and washer plate square heads shall be gunmetal to BS EN 1982:1999, 1400-LG2, seating-washers shall be vulcanized synthetic rubber to BS 3457: 1973 Clause 6 and head sealing '0' rings shall be to BS EN 681-1: 1996 Class D or E.

N.2.3 End Connections: Inlets and outlets of valves shall be internally threaded to BS EN ISO 228-1, Class B, Table 4M to fit threaded specials to polyethylene pipe.

N.3 Taps for Hose Connections

N.3. 1 Taps for hose connections shall be globe valves to BS 5154:1991 suitable for NP16, comprising ductile iron or brass hose outlets to match hose connection tips, enclosed in blockwork boxes for buried installation with ductile iron hinged lockable covers.

N.3. 2 Factory protection of external surface of boxes shall be hot applied coal tar or bitumen to BS 4164:2002 or BS 3164:1991 respectively. The minimum coating thickness shall be 250 microns.

N.3. 3 Box locking keys shall be manufactured from ductile iron and supplied at the rate of 1 for every 3 boxes.

N.4 Water Meters

N.4. 1 Water flow meters shall be installed at the locations shown on the Drawings.

N.4. 2 Unless stated otherwise on the Drawings, meters shall be of the helical rotary type to Local Water Authority standards and requirements and approved by the Engineer. Meters shall be accurate to within 5% over the specified flow range.

N.4. 3 The meters shall measure the instantaneous rate of flow as well as total flow.

N.4. 4 No negative reading shall be imposed by the passage of air or suction due to the emptying of the pipe system upstream from the meter.

N.4. 5 Meters shall be made of corrosion and wear-resistant materials and shall have dial glass wipers. Meters shall be protected against unauthorized tampering

O. Valve Accessories and Operators

O.1 Valve Accessories

O.1.1 Handwheels shall be manufactured in accordance with BS 5163:2004, of cast iron to BS EN 1561:1997 Grade 10. Handwheels shall be marked 'CLOSE' with an arrow to indicate a clockwise direction of closure. Diameters and other constructional details shall be to the manufacturer's standards. Handwheels shall be supplied at a rate of 1 in 5 valves.

O.1.2 Valve caps shall be manufactured in accordance with BS 5163:2004, of cast iron or malleable iron to BS EN 1561: 1997. The valve cap set screw shall be mild steel M12.

O.1.3 Operation keys shall be the combination prising bar and lifting key type, with a 1.5 m vertical bar and a 0.5 m horizontal bar. Keys shall be supplied at a rate of 1 for every 5 valves.

O.1.4 Extension spindles for gate valves shall be manufactured from steel in accordance with BS 2470:1973 - M12, galvanized to BS 3382: Parts 1 & 2:1961, size 18 x 18 mm for valves up to 200 mm diameter and 24 x 24 mm for valves 250 mm to 400 mm diameter. The length for each valve size shall suit installation requirements. Spindles shall have cast iron or malleable iron caps and couplings to BS EN 1561:1997 on both sides of extension spindles (the cap for operating spindles and couplings for connecting to valves). Screws of caps and couplings shall be mild steel class M12.

O.1.5 Protection tubes shall be either UPVC or cast iron. The shape, size and other constructional details shall be in accordance with manufacturers' standards and/or as shown on the Drawings. Tubes shall have caps circling extension spindles.

O.1.6 Surface Boxes shall be manufactured in accordance with BS 5834-2:1983. Frames and lids shall be cast iron to BS EN 1561:1997 Grade 10. Studs, bolts, nuts and hinge pins shall be mild steel M12, chains shall be mild steel or wrought iron and lids shall have the letter 'W' cast on. Boxes shall be of the following types:

- For carriageways (wheel loads up to 11.5 tons): heavy grade type A
- For areas of light trafficking: medium grade type M
- In areas inaccessible to motorised vehicles: light grade type L

O.1.7 Lifting key sets shall be malleable iron, supplied at the rate of 1 per 5 covers installed or fraction thereof.

O.1.8 Guards for underground stop valves shall be manufactured from PVC. The shape, size and other constructional details shall be to the manufacturer's standards and/or as shown on the Drawings.

O.2 Valve Operators

Gate, butterfly and ball valves shall be manually or electrically operated depending upon their size, torque applied on the valve stem or as shown on the Drawings:

- Valves 350 mm and smaller shall be operated manually with a maximum applied torque on handwheels of 100 Nm
- Valves 400 - 500 mm shall be operated manually with a maximum applied torque of 150 Nm
- Valves of higher torque shall have appropriate thrust bearings, slides and gearboxes to fulfil these requirements
- Gate valves 600 mm and larger and ball valves shall be electrically operated using thrust bearings, gearboxes and motor actuators
- Butterfly valves 600 mm and larger shall be either manually or electrically operated as shown on the Drawings.

O.3 Manual Gearboxes

O.3. 1 Manual gearboxes shall be totally enclosed and sealed to protect moving parts from damage and corrosion. Gearboxes shall be either the spur or level type depending upon the mounting positions of valves.

O.3. 2 Components include corrosion resistant bearings, cast iron gears, cast housing covers complete with seals and gaskets and handwheel actuators. Housing covers shall have indicator windows to show the position of valves. Gearboxes shall also have stainless steel bolts.

O.4 Electric Valve Operators

O.4. 1 Electric valve operators shall consist of motorized units including gear trains mounted in cast iron housings, flange mounted electric motors, control cabinets and handwheels for manual operation.

O.4. 2 Electric valve operators shall be suitable for flange mounting directly on valve bodies, for gate valves with non-rising stems and for manual operation.

O.4. 3 Electric valve operators shall have adequate horse-power and thrust ratings to open and close operated valves smoothly in all load and pressure conditions.

O.4. 4 Components shall include adjustable mechanical stop-limiting devices to prevent over-travel of the valve in either direction. Operator housings, supports and connections to valves shall have a minimum safety factor of 5 based on the ultimate strengths of the materials used.

O.4. 5 Electric valve operators shall be weatherproof, with rugged cast iron housings and handwheels having appropriate gearing for emergency manual operation with a maximum applied torque of 150 Nm. Declutch levers shall be provided to disengage drive motors during handwheel operations and prevent handwheel rotation during power operation. Handwheels shall close valves in the clockwise direction and have arrows and the word 'CLOSE' cast on.

O.4. 6 Controls shall comprise integral electric controls enclosed within weatherproof compartments, magnetic starters and reversing controllers for motors, open-stop-close push-buttons for local operation, limit switches giving remote indication when the valve is fully opened or closed, torque switches to shut down drives on excessive thrust loads, indicator lights and control voltage transformers.

O.4. 7 Electric motors shall be the totally enclosed, squirrel cage, induction types conforming to NEMA Publication No. MG1 including characteristics, tests and ratings. Motors shall carry the maximum possible loads encountered in valve operation under all normal and abnormal operating conditions without exceeding nameplate ratings and without the inclusion of service factors.

O.5 Valve Chambers and Markers

O.5. 1 Unless shown otherwise on the Drawings all backflow preventers, gate valves, pressure regulators, electric solenoid valves, manual control valves, pressure gauges and water meters shall be installed in precast concrete access boxes of an adequate size for easy access. Access boxes shall be complete with precast concrete covers.

O.5. 2 Unless shown otherwise on the Drawings all access boxes shall be installed on a suitable level base of gravel to provide drainage.

O.5. 3 Valve markers showing the reference numbers of the valves shall be of materials and to the dimensions, shapes and details shown on the Drawings.

P. Jointing Materials

P.1 General

P.1.1 Gaskets shall be elastomeric full face 3 mm thick joint rings to BS EN 681-1:1996 with dimensions to BS 3063:1965.

P.1.2 Rings shall be elastomeric to BS EN 681-1:1996 with dimensions in accordance with the manufacturer's recommendations to suit the type of joint required.

P.1.3 Bolts and nuts shall be isometric black hexagonal to BS 4190:2001 with a minimum tensile strength of 433 MN/m^2 and a maximum elongation of 17%. After fixing, bolt projections shall be maximum of 6 mm, minimum 3 mm.

P.1.4 Washers shall be black steel to BS 4320:1968.

P.1.5 Dielectric joints shall have insulating gaskets between flanges and Teflon sleeves and washers between bolts and nuts and flanges. Joints shall be suitable for the operating pressures of systems.

P.2 Flexible Couplings

P.2.1 Flexible couplings shall be the gasketed sleeve type, allowing angular deflections and axial movements of the two joined pipe ends, maintaining permanent, leak-tight joints.

P.2.2 Flexible coupling components comprise one centre sleeve, two end followers or flanges, two rubber-compounded wedge-section gaskets and sufficient draw bolts and nuts to properly compress the gaskets. Tightening of bolts to draw the end followers together shall compress the gaskets in the recesses between the centre sleeves and followers onto the pipe ends to effect positive seals.

P.2.3 Couplings shall have diameters specifically supplied for and properly fitting the specific types of joined pipe ends. Centre sleeves shall be of adequate thicknesses and whole couplings suitable for minimum working pressures as shown on the Drawings.

P.2.4 Centre sleeve and followers shall be true circular sections, free from irregularities, flat spots or surface defects and formed from steel mill sections with spacees between sleeves and followers designed to provide confinement of gaskets.

P.2.5 Bolts shall be steel having a minimum yield strength of 2800 kg/cm^2 and ultimate strength of 4200 kg/cm^2. Bolts shall track-headed to prevent turning when nuts are tightened and threads shall be rolled with a nominal diameter larger than the shank diameter. The Manufacturer shall supply relevant information regarding recommended torques to which the bolts are to be tightened.

P.2.6 Gaskets shall be made from a synthetic rubber-base compound with other products to produce material which will not deteriorate from age, heat or exposure to air and which is resilient and able to resist cold flow of material so that the joint will remain sealed and tight indefinitely when subjected to shock, vibration, pulsation, temperature and adjustment of connected pipes.

P.2.7 Couplings shall be factory painted internally with a 5 mm coating of epoxy and externally with red primer to AWWA 203 Type B chlorinated rubber solution compatible with bitumen, coal tar and general paints.

P.2.8 Couplings shall be assembled on site in accordance with the manufacturer's instructions to ensure permanently tight joints under all conditions of expansion, contraction, shifting and settlement.

P.3 Demountable Couplings

P.3.1 Demountable couplings shall be mounted next to valves to enable easy dismantling from pipework or to permit joining pipework when butterfly valves are removed for maintenance.

P.3.2 The demountable section shall be a flanged type composed of two parts with one part sliding into the other and a free flange to compress a trapezoidal section seal to ensure watertightness. Couplings shall have locking devices as approved by the Engineer..

P.3.3 Flanges shall be constructed of steel class PN 10, PN 16 or PN 25 depending upon the coupling location on pipework and to the Engineer's approval.

P.3.4 Couplings shall have diameters specifically supplied for and properly fitting the types of joined ends of pipes and valves. Couplings shall permit tightening of end flanges without risk of misalignment. Seals shall be locked after end joints are tightened.

Q. Irrigation Valve Accessories and Operators

Q.1 Valve Boxes

Valve boxes shall be manufactured from glass reinforced plastic (GRP) or plastic conforming to the following specifications.

Q.1.1 GRP Valve Boxes

A. GRP Valve Boxes shall be designed to suit site conditions and loadings. GRP shall be manufactured from E-glass type fibres and thermosetting resin and shall incorporate a corrosion resistant liner. Glass fibres shall be compatible with the resins used. Liners shall comprise inner faces of a smooth hard suitably reinforced resin rich layer. Exterior surfaces of valve boxes shall be be resin rich.

B. Inside surfaces of the valve boxes shall be hard, durable, free of tackiness, bulges, dents, ridges or other defects that result in a variation of the inside dimensions of more than 3 mm.

C. No glass fibre reinforcement shall penetrate the interior surfaces of valve box walls, and any glass fibre reinforcement on the exterior surface shall be thoroughly impregnated with resin.

D. The glass content shall be determined by ignition loss analysis in accordance with ASTM Method D 2584 or BS EN ISO 1172:1999.

Q.1.2 Plastic Valve Boxes

Plastic valve boxes shall be manufactured from a high impact, acid and heat resistant, self extinguishing, hard, durable, low coefficient of expansion PVC compound.

Q.2 Programme Controllers

Q.2.1 Programme controllers shall be hybrid types (combining electro-mechanical and micro-electronic circuiting), with four independent programmes capable of fully automatic or manual operation of the remote solenoid valves, 14-day calendar dials for every day or every other day or any sequence starts, time-setting control up to 60 minutes per station in 2 minutes increments 23 starts per day. The number of stations shall be as indicated on the Drawings or in the Bill of Quantities. The maximum number of 24 V AC solenoid valves that can be controlled by a station is 4. The controller shall allow for valve power output to be interrupted without affecting the controller timers.

Q.2.2 The controller shall have a start circuit to activate a remote pump start relay to run the pump during the irrigation cycle.

Q.2.3 The controller shall allow for opening the first remote control valve before operating the pump and also for closing the last remote control valve within 15 seconds after stopping the pump.

Q.2.4 The controller shall be installed in a pedestal mounted, weatherproof, heavy-duty, locking steel cabinet. The pedestal shall include terminal strips for quick connection of cables.

Q.2.5 Controllers shall accept a 220 V 50/60 cycle current; with 24 VAC solenoid valves; output power surge protection; a master on-off switch and one arrestor for each valve wire and for the common or earth wire.

Q.2.6 Controllers shall be from the same manufacturer as the remote control valves.

Q.3 Cabling for Irrigation Control

Q.3.1 Low voltage wiring from automatic controllers to remote control valves shall be directly buried, 600 volt solid copper single conductor wire with heat resistant insulation of a minimum 0.4 mm thickness. The Contractor shall submit proposed low voltage wire routing shop drawings for the Engineer's approval prior to installation. The low voltage wire shall be encased in 5 mm diameter conduits.

Q.3.2 Medium voltage cables shall conform to the requirements of BS 5467:1997 or IEC 60502. Cables shall be 600/1000 volt grade, multicore stranded copper conductors, cross-linked polyethylene (XLPE) insulated and UPVC oversheathed type. The service cable for irrigation controllers shall be 3 core 10 mm^2 minimum.

Q.3.3 Conductors shall be annealed stranded copper in accordance with BS 6360:1991. Conductor insulation shall be moisture and heat resistant to 90^{o}C, conforming to BS EN 60811. The cable cores, unless otherwise approved by the Engineer, shall be coloured as follows:

- Single phase system: red (phase), black (neutral), green or green/ yellow (ground).

8.03.3 WORKMANSHIP

A. General

A.1 Prior to installation, the Contractor shall inspect for cleanliness of bores, seating surfaces and handling damage, cracks, missing parts and tightness of pressure-containing bolting.

A.2 Gates and hydrants shall be set to the closed position before installation.

A.3 Valves and hydrants shall be operated through one complete opening and closing cycle at the settings at which they are to be installed to ensure correct functioning.

B. Installation

B.1 Valves

B.1.1 Valves shall be set and jointed to pipes in accordance with the specifications, standards and manufacturer's instructions.

B.1.2 Valves shall be provided with class 210/25 concrete pads as shown on the Drawings so that the adjacent pipes do not support their weight.

B.1.3 Valves without concrete pads shall be placed on firm footings to prevent settling and excessive strain on connections to pipes.

B.1.4 Valves shall not be used to bring misaligned pipes into alignment during installation.

B.1.5 The Contractor shall inspect all pressure-containing bolting (bonnets, seal plates and end connections) for adequate tightness after installation but prior to field testing.

B.2 Sluice Gates

B.2.1 The Contractor shall install gates, walls thimbles, operating mechanisms, stems and stem guides in accordance with the manufacturer's drawings and recommendations. Care shall be taken to avoid warping the frame and to maintain the tolerance between seating faces.

B.2.2 The Contractor shall protect tapped holes in thimbles during concreting and setting.

B.2.3 The Contractor shall protect the surfaces of thimbles and gates from concrete spillage, paint, oil and debris.

B.2.4 The Contractor shall support thimbles to prevent shifting during pouring and provide horizontal and vertical bracing to prevent distortion.

B.2.5 The Contractor shall tighten nuts in sequence after setting.

B.2.6 The Contractor shall adjust and lubricate the entire assembly after installation.

B.2.7 The Contractor shall operate the completed sluice gates through one complete cycle to ensure proper functioning.

B.3 Penstocks

B.3.1 General

B.3.1.1 Penstocks shall be water-tight under the conditions of head and direction of flow as stated in the Drawings or as specified by the Engineer.

B.3.1.2 All bolt holes shall be drilled and spot faced.

B.3.1.3 Simple templates shall be supplied for all penstocks over 1 m^2 as soon as possible after approval of drawings in order to position the holes for holding down bolts.

B.3.2 Installation

B.3.2.1 Each tube shall be clearly and permanently engraved to indicate the position of the penstock.

B.3.2.2 For each penstock, the wall thimble, operating mechanism, stem and stem guides shall be installed in accordance with the manufacturer's recommendations. Tolerances between seating faces shall be maintained and any warping avoided.

B.3.2.3 Tapped holes in thimbles shall be protected during concreting and setting. Surfaces of thimbles and gates shall be protected from concrete spillage, paint, oil and debris. Thimbles shall be supported to prevent movement during pouring and braced horizontally and vertically to prevent distortion.

B.3.2.4 Nuts shall be tightened in sequence after setting and the entire assembly shall be cleaned, adjusted and lubricated after installation.

B.3.2.5 Penstocks shall be operated through one complete cycle on installation to ensure proper functioning.

B.3.2.6 Penstocks shall be protected against the action of external agents with one coat of approved bituminous compound applied cold by brush after installation. Buried bolts, etc. shall be protected against corrosion with approved paint or polyethylene wrapping.

B.4 Hydrants

B.4.1 Hydrants shall be joined to pipes in accordance with the specifications, standards and manufacturer's instructions.

B.4.2 Hydrants shall be set to established grades as directed by the Engineer.

B.4.3 Hydrants shall be set plumb with nozzles and parallel with or at right angles to the curb. Where hydrants have single pumper nozzles, these shall be set facing the curb. Where hydrants have two hose nozzles 90^{o} apart, these shall be set with each nozzle facing the curb at a 45^{o} angle.

B.5 Field Protection

B.5.1 Valves shall be protected by a coat of bituminous compound, as approved by the Engineer, applied cold by brush after pressure testing on pipelines has been completed.

B.5.2 One coat of paint shall be applied to hydrants, of a colour specified by the Engineer, after backfilling and surface restoration has been completed.

B.5.3 Gates shall be protected with one coat of bituminous compound, as approved by the Engineer, applied cold by brush after installation.

B.5.4 Buried bolts shall be protected against corrosion with a paint approved by the Engineer or by polyethylene wrapping.

F. Installation of Irrigation System Components

F.1 Installation of Valves

F.1.1 Prior to installation, valves shall be inspected for cleanliness of bore, seating surfaces etc. and for handling damage, cracks, missing parts and tightness of bolting. Valves shall be in the closed position before installation.

F.1.2 Valves shall be operated through one complete opening and closing cycle in the position in which they shall be installed to ensure proper functioning.

F.1.3 Valves shall be set and jointed to the pipe as specified for laying and jointing pipes and in accordance with the manufacturer's recommendations. Each valve shall be provided with a concrete pad as shown on the Drawings so that the pipe does not support the weight of the valve. Valves shall not be used to spring a misaligned pipe into alignment during installation.

F.1.4 All stressed bolts (bonnets, seal plates and end connections) shall be inspected for adequate tightness after installation and prior to field-testing.

F.1.5 Valves shall be protected against the action of external agents by a coat of approved bituminous compound, applied cold by hand brushing after pressure tests on pipelines have been completed. Buried bolts shall be protected against corrosion, with approved paint or polyethylene wrapping.

F.2 Installation of Other Irrigation System Components

F.2. 1 Irrigation components forming a control head shall be located in downstream order as follows: backflow preventer, control valve, fertilizer applicator and gate valve, pressure gauge, filter, pressure gauge, electric solenoid valve, water flow meter and pressure regulator.

F.2. 2 Filter and fertilizer applicator equipment shall be mounted on a concrete pad forming an integral installation. The filter shall be located downstream of the fertilizer applicator to prevent contamination from the injection process. The concrete pad shall be Class 210/20 with dimensions as recommended by the equipment manufacturer.

F.2. 3 The installation of miscellaneous components of the system shall be in accordance with the manufacturer's instructions.

8.03.4 MEASUREMENT

A. Valves and Accessories

A.1 Valves and taps shall be paid for per unit installed according to the size and type indicated in the Bill of Quantities.

A.2 Rates for gate and butterfly valves shall include for:

1) Supply of valves as specified,
2) Lowering into the trench and installing,
3) Over-excavation for concrete supports and boxes,
4) Concrete supports and thrust blocks. Concrete work shall include all items required for Concrete Work and Concrete Structures,
5) Appropriate fittings and/or couplings and dismantling joint for connecting to adjacent pipe or fitting,
6) Flanged and socket adaptors necessary for connecting to adjacent spigot ends,
7) Valve chambers complete with cover lock and rungs as shown on Drawings for valves placed in chambers,
8) Valve surface box complete with cover, lock and key and concrete surround for directly buried valves,
9) Bolts, nuts, gaskets, operating keys, hand wheels and others,
10) Ancillary works and material required,
11) Painting, lining and coating,
12) Extension spindles plus square nuts to fit spindles.

A.3 Rates for air valves shall include for:

1) Supply of valves as specified,
2) Tees and/or saddles for connecting to the main line,
3) Isolating gate valves,
4) Drilling and fixing the flanged spool outlets for air valve connections,
5) Ancillary works and materials required,
6) Installing, painting, coating and testing,
7) Concrete valve chamber complete with cover and lock as shown on the Drawings.

A.4 Rates for drain and flush valves include for:.

1) Supply of material, items forming the complete unit, as shown on the Drawings, including pipes, flexible couplings, valves, flanged pipes, duckfoot elbows, housing and polyethylene pipes
2) Bolts, nuts and gaskets.
3) Thrust and support blocks.
4) Valve chambers complete with covers, locks, surface boxes and rungs.
5) Factory painting, lining and coating.
6) Ancillary works and materials.
7) Polyethylene pipe diameter 150 or 200 mm, 50 m long with protection and anchorage at outlet to allow free discharge to the drainage outfall.
8) Ductile iron pipe and flexible couplings between invert level tees and valve chambers.
9) Installing, painting, coating and testing.

A.5 Rates for taps for hose connections shall be paid per connection installed.

A6 Rates for taps for hose connections shall include:

1) Supply of all materials including pipes, fitting specials and service boxes and covers.
2) Supply of stopcocks and saddles on mainline. Excavation bedding and backfilling, concrete works and reinstatement.
3) Installation and connection to new network and to the service box, or to the existing service connection and testing.

B. Sluice Gates and Penstocks

Sluice gates and penstocks shall be measured and paid for per unit installed according to size and type indicated in the Bill of Quantities.

Rates for sluice gates and penstocks shall include for:

1) Gates.
2) Frames, rubber bottom seals, anchor bolts, stem and stem guides.
3) Lifts with wall brackets, anchor bolts and handwheels.
4) Cleaning and painting.
5) Assembly, installation, testing and adjustment.
6) Stop planks.

C. Fire Hydrants

C.1 Fire hydrants shall be paid for per unit installed according to the type indicated in the Bill of Quantities.

C.2 Rates for fire hydrants shall include for:

1) Supply of material, items forming the complete unit including pipes, flexible couplings, valves, flanged pipes, duckfoot elbows, housing and polyethylene pipes
2) Bolts, nuts and gaskets.
3) Thrust and support blocks.
4) Valve chambers complete with covers, locks, surface boxes and rungs.
5) Factory painting, lining and coating.
6) Ancillary works and materials.
7) Installing, painting, coating and testing.

D. Irrigation System Components

D.1 Rates for irrigators (irrigation equipment and accessories excluding drip emitter distribution tubing) shall be measured by the number of each type and size installed, completed and accepted be paid per unit installed

D.2 Drip emitter distribution tubing shall be measured by the linear metre of each size installed, completed and accepted.

D.3 Spares for the irrigation system shall be a Prime Cost Item and shall be measured by the number of each type and class of spare part authorized by the Engineer, purchased by the Contractor, handed over and accepted.

D.4 Rates for irrigators shall include for:

1) Supply of material, items forming the complete unit as shown on the Drawings,
2) Bolts, nuts, gaskets and operating keys,
3) Excavation and backfilling,
4) Supply of equipment and appropriate fittings and or couplings for connection to adjacent networks
5) Valve boxes complete with locking covers and marker posts
6) Lowering into the trench and installing,
7) Installing, painting, coating, lining and testing

PAY ITEMS		**UNIT OF MEASUREMENT**
(8.3.1)	Valves *(state type & size)*	Number (No)
(8.3.2)	Taps for Hose Connection *(state type & size)*	Number (No)
(8.3.3)	Sluice Gates *(state type & size)*	Number (No)
(8.3.4)	Penstocks *(state type & size)*	Number (No)
(8.3.5)	Fire Hydrants *(state type & size)*	Number (No)
(8.3.6)	Irrigation Program Controllers *(state type & size)*	Number (No)
(8.3.7)	Irrigators *(state type & size)*	Number (No)
(8.3.8)	Drip Emitter *(state type & size)*	Linear metre (m)
(8.3.9)	Spares for Irrigation System	Item

SECTION 8.04 SURROUND, HAUNCHING, ENCASEMENT & THRUST BLOCKS

8.04.1 SCOPE

The work covered in this section includes in-situ concrete work and other fills necessary for the installation of drainage pipe installation.

Concrete work shall comply with the appropriate requirements of Section 5: Concrete, Steel and Structures.

8.04.2 MATERIALS

A. Compressible board shall be 20 mm thick compressible fibrous board or similar material approved by the Engineer.

B. Fill Material Under and Around Pipes

B.1 Material under and around pipe (pipe surround and backfill) shall comply with the appropriate requirements of Specification Section 2: Earthworks.

B.2 Concrete bedding shall be in situ concrete Class 110/25.

B.3 Concrete encasement, thrust blocks, arches and haunches shall comprise in-situ concrete Class 250/20.

8.04.3 WORKMANSHIP

A. Placing Concrete

A.1 After the laying of pipes in the trench, concrete shall be placed and compacted under the pipes to provide a solid and uniform surround.

A.2 After pipe jointing has been completed the outstanding concrete or haunching shall be placed and compacted on both sides simultaneously.

A.3 Vertical construction joints shall be formed in the concrete at the faces of pipe joints using compressible board and finished to the profile of the concrete and pipes. Gaps between spigots and sockets shall be filled with resilient material approved by the Engineer.

B. Placing Material Other Than Concrete

B.1 Surround material shall be placed in the bottom of prepared trenches and hand tamped to the minimum thicknesses specified on the Drawings or instructed by the Engineer.

B.2 When the pipe has been laid, additional material or haunching shall be placed in successive layers not exceeding 150 mm thick simultaneously on both sides. All spaces between pipes and the sides of trenches shall be filled and carefully hand tamped without disturbing the pipes.

C. Thrust Blocks

Thrust blocks shall be provided at bends and other fittings on pressure pipelines. The additional excavation required shall be undertaken after the pipeline has been jointed. No pressure shall be applied to the thrust block until the concrete has matured for at least 3 days.

8.04.4 MEASUREMENT

Concrete encasement for pipelines shall be measured by the cubic metre of concrete calculated on the basis of dimensions indicated on the Drawings after deducting the pipe section.

All other material and work items mentioned above, including compressible boards, surround, backfill and haunching material and thrust blocks shall not paid for separately but shall be included in their respective pay items as indicated elsewhere in the specification.

PAY ITEM		UNIT OF MEASUREMENT
(8.04.1)	Concrete Encasement for Pipes	Cubic Metre (m^3)

SECTION 8.05 MANHOLES, CHAMBERS AND GULLIES

8.05.1 SCOPE

The work covered in this Section includes the furnishing of all materials, construction, installation, connection and completion of manholes, catch pits, valve chambers, kerb inlets, interceptors, access shafts, inspection chambers and gullies for drainage, sewer and water supply systems.

8.05.2 GENERAL

A. Excavation and backfilling shall comply with the appropriate requirements of Section 2: Earthworks.

B. Concrete work shall comply with the appropriate requirements of Section 5 Concrete, Steel and Structures.

C. The method of reinforcing shall conform to the requirements of Section 5.03: Steel Reinforcement.

8.05.3 MATERIALS

A. Concrete shall conform to the requirements as specified in Section 5.01: Concrete Mixes and Testing.

B. Reinforcement shall conform to the requirements as specified in Section 5.03 Steel Reinforcement.

C. Structural steel shall conform to the requirements as specified in Section 5.16 Structural Steelwork and Metal Components.

D. Pipes shall conform to the requirements of Section 8.02: Pipes and Appurtenances or Section 5.13: Concrete Pipe Culverts as appropriate

E. Precast concrete manhole sections shall be manufactured in accordance with BS EN 1917:2002 using reinforced concrete Class 250/20. Cement shall be ordinary Portland cement. to BS EN 197-1: 2000.

F. Cast in situ units shall be constructed in plain and reinforced concrete class 210/25 and 250/20 respectively. Cement shall be ordinary Portland cement to BS EN 197-1: 2000.

G. Bricks shall be manufactured in accordance with BS 3921:1985 and BS EN 772:1998.

H. Precast concrete blocks for masonry walls shall conform to BS EN 771-3: 2003 and BS EN 772-2:1998.

I. Vitrified clay pipes and tiles shall conform to the requirements as specified in

- AASHTO M65: Vitrified clay pipes, extra strength, standard strength and perforated clay drain tiles
- AASHTO M179: Clay drain tiles

J. Corrugated aluminium alloy culverts and underdraws shall conform to the requirements as specified in AASHTO M196: Corrugated Aluminium Alloy Culverts and Underdrains

K. Grey cast iron castings shall conform to AASI-ITO M105 (ASTM A48) Class 25 or higher. Castings shall be manufactured to the sizes and dimensions shown on the Drawings.

L. Test bars shall be prepared and tested as specified in AASHTO M105.

M. Steel castings: mild to medium strength castings shall conform to AASHTO M103 (ASTM A27). Unless otherwise shown on the Drawings or instructed by the Engineer, castings shall be grade 65-35 fully annealed. Steel castings shall conform to the dimensions shown on the Drawings. Test bars shall be prepared and tested as specified in AASHTO M 103.

N. Wrought iron plates and shapes shall conform to the dimensions shown on the Drawings. Rolled wrought iron bars and shapes shall conform to the requirements of ASTM A207. Wrought iron plates shall conform to ASTM A42.

O. Covers and frames shall be manufactured from ductile iron in accordance with BS EN 124:1994, non-rock, locking and solid tops. The wording on covers shall indicate the nature of the network (water supply, sewage, stormwater, etc). Grades of covers shall be as follows:

- For roadways: Grade A, heavy duty test load 40 tons
- For sidewalks, carriage drives and cycle tracks: Grade B medium duty test load 25 tons
- For footpaths and fields: Grade C light duty, test load 7 tons

P. Manhole covers shall be of a circular pattern unless otherwise indicated on the Drawings. Frames shall be provided with openings for fixing bolts for solid frame embedment into manhole concrete necks. Covers and frames shall be coated with a bitumen based compound to BS 3416:1991 with a minimum thickness of 200 microns.

Q. Road Gully Gratings shall be manufactured in accordance with BS EN 124:1994, non-rock and coated in accordance with BS 3416:1991 with a minimum thickness of 200 microns. Types of gratings to be used shall be as follows:

- Carriageways: Grade A, minimum test load 40 tons.
- Footpaths, cycle tracks and fields, light duty, test load 7 tons.

R. Step Irons shall be manufactured in accordance with BS EN 13101: 2002.

S. Steel Ladders shall be manufactured in accordance with BS 4211:2005, mild steel, galvanized to BS EN ISO 1461:1999 with 200 grams of zinc per square metre.

T. Safety Chains shall be 12 mm diameter wrought iron short link chains, galvanized in accordance with BS EN ISO 1461 with 200 grams of zinc per square metre.

U. Guardrails shall be either of the following:

- Tubular mild steel, medium grade to BS EN 10255:2004 with screwed joints, galvanized to BS EN ISO 1461:1999 with 200 grams of zinc per square metre.
- Round steel solid bars to BS 6722:1986 with welded joints galvanised in accordance with BS EN ISO 1461:1999 with 200 grams of zinc per square metre.

V. Fixing bolts shall be manufactured from steel and of a type suitable for the particular purpose and to the approval of the Engineer. When used to fix galvanized material, washers shall be galvanized and fixing bolts and nuts cut to pre-plating limits and electroplated with zinc to BS EN ISO 1461:1999.

W. Coatings

Internal surfaces of precast concrete manholes and chambers shall be treated with a coal tar or bitumen epoxy coating if so detailed on the Drawings.

External surfaces of precast concrete manholes and chambers shall be protected with waterproofing bitumen supplied and applied in accordance with the requirements of Section 5.15 of Section 5: Concrete, Steel and Structures.

8.05.4 CONSTRUCTION

A. Manholes and Inspection Chambers

A.1 Manholes and inspection chambers shall be constructed from in-situ concrete or precast concrete as shown on the Drawings or as proposed by the Contractor and approved by the Engineer. In-situ units shall be constructed in accordance with Specification Section 5: Concrete Works.

A.2 Precast units shall be cast in steel watertight forms for at least 3 weeks before the sections are used. Precast units shall be assembled on an in-situ concrete base and bedded on and sealed with cement mortar. Prior to fixing, joints of precast units shall be either completely coated with bituminous material or sealed with a preformed jointing strip, all in accordance with manufacturer's instructions or as detailed on the Drawings and approved by the Engineer. Any surplus jointing material extruded inside the chamber or shaft shall be trimmed off and joints shall be pointed on completion. This work shall be left undisturbed for 7 days. Precast concrete cover slabs shall be bedded on cement mortar.

A.3 Channels in bottoms of manholes shall be smooth, semi-circular with a diameter equal to the adjacent sewer pipes. For straight- through manholes, channels shall be constructed from half pipe sections. Changes in direction of flow shall be accommodated with smooth curves as large as the manholes permit. Changes in the size and grade of channels shall be gradual and even.

A.4 Benching shall be formed in concrete Class 110/25 rising vertically from the top of the channels to the level of the soffit of the outlet pipe and thereafter sloping upwards at 1 in 10 to the walls. Within 3 hours of completion of benching, a coat of sulphate resisting cement-sand mortar 1:2 shall be applied and smoothed using a steel trowel.

A.5 External faces of manholes and chambers shall be protected by three layers of brush-applied bituminous paint with a minimum thickness of 600 microns and in accordance with Section 5: Concrete Steel and Structures or as detailed on the Drawings or as specified by the Engineer.

A.6 Internal faces of manholes and chambers shall be covered with four coats of coal tar epoxy paint, 70% epoxy and 30% coal tar as detailed on the Drawings or as approved by the Engineer, applied by brush in accordance with the manufacturer's instructions. The minimum thickness of coating shall be 1000 microns.

A.7 Step irons shall be cast into precast units or grouted into preformed mortises. Step irons shall not be used as lifting eyes. Devices for lifting and handling precast units shall be provided on exterior faces only.

A.8 Top courses of brickwork or concrete rings shall be completed only after completion of the surrounding roadworks to ensure that the cover is flush to the finished surface.

A.9 Covers and gratings shall be embedded in mortar and seated firmly using fixing bolts. Covers shall be positioned centrally over openings and be level and square with surrounding the finish.

A.10 Manholes shall be tested on completion by plugging inlets and outlets, filling with water and standing for at least 24 hours or such longer period to allow for complete absorption. The manhole shall then be refilled with water. The allowable leakage after refilling over 24 hours shall not exceed 1% of total volume of the manhole. If a manhole fails this test it shall be made good and retested.

B. Valve Chambers

B.1 Valve chambers shall be constructed using in-situ or precast concrete or blockwork as shown on the Drawings.

B.2 External faces of valve chambers shall be protected by two layers of brush-applied bituminous paint with a minimum thickness of 400 microns and in accordance with Section 5: Concrete Steel and Structures or as detailed on the Drawings or as specified by the Engineer.

B.3 Covers shall be embedded in mortar and seated firmly using fixing bolts. Covers shall be positioned centrally over openings and be level and square with surrounding finishes.

C. Road Gullies and Kerb Inlets

Road gullies and kerb inlets shall be constructed using in-situ or precast concrete to the size and shape indicated on the Drawings and conforming to the construction requirements for manholes.

8.05.5 MEASUREMENT

A. Manholes, drop inlets, catch basins, catchpits, kerb inlets, ditch inlets and ditch outlets shall be measured by the number of each type constructed, completed as shown on Drawings and accepted including protective painting, furnishing and installation of all materials, frames, grates, covers and steps.

B. Channel grating basins shall be measured by the linear meter of each clear opening width, constructed, completed and accepted including furnishing and installation of all materials, frames and grates.

C. No separate measurement or payment shall be made for any excavation, shoring, sheeting or backfilling or for breaking into existing pipes, channels or culverts in order to install new manholes, catch basins, catchpits, drop inlets, kerb inlets, ditch inlets, ditch outlets and channel grating basins; all such work being considered subsidiary to the relevant pay items.

D. No separate payment shall be made for blinding, protective and bituminous painting, equipment, forms, tools, furnishing and placing materials, labour or any other item necessary for the proper completion of the work.

PAY ITEMS	**UNIT OF MEASUREMENT**
(8.05.1) Manholes (*Specify type, size and depth*)	Number (No)
(8.05.2) Road Gully (*Specify type, size and depth*)	Number (No)
(8.05.3) Interceptors (*Specify type, size and depth*)	Linear Meter (m)
(8.05.4) Kerb Inlet (*Specify type, size and depth*)	Number (No)
(8.05.5) Catch Basin (*Specify type, size and depth*)	Number (No)
(8.05.6) Inspection Chamber (*Specify type, size and depth*)	Number (No)
(8.05.7) Access Shaft (*Specify type, size and depth*)	Number (No)
(8.05.8) Valve Chamber (*Specify type, size and depth*)	Number (No)
(8.05.9) Catchpit (*Specify type, size and depth*)	Number (No)
(8.05.10) Ditch Inlet (*Specify type, size and depth*)	Number (No)
(8.05.11) Ditch Outlet (*Specify type, size and depth*)	Number (No)
(8.05.12) Channel Grating (*Specify type and size*)	Linear metre (m)
(8.05.13) Drop Inlet (*Specify type, size and depth*)	Number (No)