



REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

REHABILITATION OF REMAINING ROADS
FOR LOT 3
JEZZINE CAZA

JEZZINE ENTRANCE

Final Tender Documents

Volume II
Technical Specifications

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(آيس) المكتب الهندسي الاستشاري

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REHABILITATION OF SELECTED ROAD LINKS IN LEBANON

LOT 3 – JEZZINE CAZA

JEZZINE ENTRANCE

VOLUME 2: TECHNICAL SPECIFICATIONS

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General Requirements

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(GENERAL REQUIRMENTS)

1-1-1 General Description

The Works include the

REHABILITATION OF SELECTED ROAD LINKS IN LEBANON

LOT 3 – JEZZINE CAZA – JEZZINE ENTRANCE

The Project aims to upgrade the transport connectivity in Lebanon by providing road rehabilitation and maintenance for selected primary, secondary and tertiary roads that are under REP.

The road under rehabilitation scope of works, is the remaining road sections in Jezzine Caza for Jezzine Entrance.

(GENERAL REQUIREMENTS)

1-1-2 The Works

The rehabilitation and maintenance of these Roads shall focus on preserving the Road facility during the projected design life, in a good Condition to provide an acceptable level of service for the users.

The construction and rehabilitation work include the following:

- Pavement reconstruction (aggregate base course, bituminous base course.).
- Pavement rehabilitation (Milling and overlay, deep patching...).
- Structural concrete repairs.
- Storm water drainage improvement and construction of new culverts, ditches and channels.
- Sewer network construction.
- Rehabilitation of existing side barriers (New Jersey, concrete barrier and guardrails.)
- Improvement of median separators, sidewalks and curbs where necessary.
- Construction of new stone masonry Guard walls.
- Road marking and signing.
- Appropriate traffic calming measures such as speed humps, speeds bumps and speed tables.
- Thermoplastic sheets with various signs and warnings.
- Relocation of hazardous electrical, telephone or street lighting poles.
- Traffic management measures during construction, reinstatement of roads disturbed by the works and tapering to the existing roads as necessary.
- Concrete Piling Works
- Reinstatement of existing stone wall

N.B: Upon request, the Contractor shall deliver at no extra cost the milled asphalt material to the local municipalities for their own use.

1-1-3 Concurrent Work

Other work not forming part of the Contract will be carried out by the Employer or other contractors or public bodies during the execution of the works.

Allow for the coordination of this work to enable the installation to progress without disruption to the completion of the works. Allow for the provision of all necessary temporary facilities as required and afford all reasonable access and assistance to enable the completion of these works in a timely manner.

1-1-4 Restraints

The maintenance of the existing utilities and access during the whole period of construction (i.e. electrical supplies water supply sewage disposal and telecommunications) imposes serious restraints upon the programming of the works. The Contractor is to consider carefully and incorporate all the restraints into his program of works and allow for same in his contract price.

1-1-5 Phasing Of Work

The phasing of the work will be developed by the Employer and Contractor upon consideration of the contractors proposals for the program of works and construction activities. The contractor has to prepare his program in accordance with section 3-1 of these documents.

The Contractor shall prepare his program to ensure that proper outlets will be provided to adjacent networks as soon as practicable and especially before wet seasons.

1-1-6 Sectional Completion

The Works are to be completed and will be taken over by the Employer, in accordance with Clause 48 of the Conditions of Contract, after agreement of the construction program.

1-1-7 Restrictions on Methods of Working

The contractor is to ascertain from the appropriate authorities any restrictions on the methods of working, incorporate into works and include in the Contract price.

1-1-8 Sequence of Construction

The limited workspace and numerous utilities in the Project Area calls for a thorough and well studied construction sequence. The Contractor shall prepare a construction sequence in conformity with his construction program. Such a sequence / program has to include procedures regarding maintenance of service during construction as well as utility diversion to ensure such service.

1-1-9 Restrictions on Times of Working

The contractor is to ascertain from the various authorities the local restrictions during the completion of the works. The contractor is to assume for the purposes of the tender that normal working hours shall be from dawn to dusk.

1-2 The Site

1-2-1 General

The Site is described on drawings; the contractor shall make all necessary arrangements, including payment if need be, regarding any land outside the Site that may be needed as work areas. The Employer will not acknowledge any liability in respect of such land. The Contractor shall also be responsible for insuring that all roads and temporary facilities needed are sufficient to divert traffic adequately.

1-2-2 Contractors Site Compound

The Contractor shall locate and select sites outside the right-of-way for use of his plant, equipment, site offices, residences, Temporary Works or any other uses which are essential during the execution of the Contract. The Contractor shall take the necessary measures for using these sites and shall be responsible for all expenses that may become due in return for such use. Prior to using any land owned by public or private owner outside the Site, the Contractor shall obtain the approval of the concerned Authorities and the Project Manager/Engineer.

1-2-3 Existing Utilities and Obstacles

Utilities shall include, but not be limited to, existing water lines, gas lines, sewer lines, wire lines, service connections, water and gas meters and valve boxes, light poles and masts, pylons, cableways, signals, and all utility appurtenances within the limits of the proposed construction.

The Contractor shall :

- Take into account that the diversion works will be carried out to the requirements and approval of the Utility Owners and/or under their supervision, and that where required by the Utility Owners specialist diversion works be carried out by accredited specialist Contractors
- Verify and identify by excavating trial pits and other measures including, detection means existing utilities. Map these utilities and prepare detailed and accurate existing utilities drawings identifying after coordinating with the respective authorities the utilities that are in service and those that are dead or abandoned. Submit to the Project Manager/Engineer and to the Utility Owners existing utilities Drawings that are accurate and detailed giving location of utilities in plan and section with all pertinent data of the respective utility
- Work out and develop in coordination with the Utility Owners and the Project Manager/Engineer approved utilities diversion schemes as will be required, and also to enable execution of the Contract Works and maintain continued utilities services in the Area, and to the users

- Execute and provide superintendence for the execution of the utility diversions whether they are carried out by the Contractor directly or by other parties employed by him
- Provide accurate as Built Drawings of all permanent utility diversions that are executed under the Contract
- Include activities for such works in the Program of Work
- Be responsible for safeguarding and protecting from damage, all utilities and appurtenances encountered during the Works and be responsible for the costs of making good any damage thereto, arising out of his own negligence.

Existing Obstacles shall include, but not be limited to existing, buildings, bridges and the like, walls, fences, gates, wells, septic tanks, manholes, pits, pipes, culverts, roadways, sidewalks, signs and rubbish dumps, whether or not shown on the Drawings. The contractor shall, at the commencement of the Contract, examine the Site and identify/verify all obstacles within the right-of-way above or below ground, and shall record all such information on suitable Site Drawings which shall be submitted to the Engineer within the agreed program but prior to commencement of that part of the work.

1-2-4 Utility Diversions

The necessary utility diversions, either temporary or permanent, shall be carried out by the Contractor. Alternatively, the Employer may make arrangements for such works to be executed by other parties, normally the Utility Owners. The Contractor shall take into account that the diversion works will be carried out to the requirements and approval of the Utility Owners and/or under their supervision.

2- DOCUMENTS AND DRAWINGS

2-1 Documents Generally

The Documents are arranged in four volumes namely :

Volume One	Bid Conditions and Procedures
Volume Two	Conditions of Contract
Volume Three	Technical Specifications
Volume Four	Bill of Quantities
	Drawings

2-2 Drawings

2-2-1 Contract Drawings

Contract Drawings are detailed on the list of Drawings, Volume 4 Drawings.

2-2-2 Dimensions and Details

Drawings are not to be scaled. Take all sizes from the dimensions shown on the Drawings or, where appropriate, as measured on site. Use detailed drawings in preference to layout drawings.

2-3 Drawings Etc. Provided by the Contractor

2-3-1 General

The Engineer will supplement the Contract Drawings with further drawings issued in accordance with sub-clause 7.1 of the Conditions of Contract as he deems necessary. The Contractor shall prepare all other drawings required for Temporary Works and for fabrication and coordination of trades and prepare all shop drawings and other drawings and documents required under the Contract, in addition to drawings for work to be designed by the Contractor.

2-3-2 Design

The Contractor shall provide and maintain a design office and design personnel to provide the coordination, control and development of the detailed construction design of the works. The Contractor is required to develop, where necessary, the Engineer design intent by providing the detailed drawings to enable the construction of the works.

2-3-3 Design and Shop Drawings

The Contractor shall prepare and submit for approval, design and shop drawings, specifications, calculations, manufacturers' data etc. as required by the Specification or instructed by the Engineer in good time to meet the program (including an allowance of 30 days for Engineer's approval and extra time for resubmission in the case of rejection) and, in any case, a minimum of 45 days before the work is to be commenced or order placed, as appropriate. Drawings shall be carefully checked before submission to ensure that no conflict exists with other parts of the work.

2-3-4 Supporting Data

Supporting Data such as manufacturers' standard details, performance standards etc. are to be in English, or accompanied by a translation, and are to be properly referenced to the Drawings and Specifications and to be presented in accordance with Procedures Note 2: Submittals for Product Data (included at the end of this Section).

2-3-5 Procedure for Submission and Approval

- (1) Submit two copies of drawings and other documents for approval to the Engineer.
- (2) Within 30 days of receipt at the Engineer's design office, the Engineer will return one copy of the drawings stamped as:
 - (a) approved, or
 - (b) approved subject to amendments shown on the returned copy or in an accompanying letter, or
 - (c) rejected, with recommendations for resubmission.

- (3) In the case of approval, work may be commenced or orders placed.
- (4) In the case of approval with qualifications, work may be commenced or orders placed, at the Contractor's risk, providing the qualifications are implemented. Submit revised drawings for approval.
- (5) In case of rejection, resubmit until approval is obtained.
- (6) Provide four copies, and reproducible copy if required, of all approved material in accordance with the Conditions of Contract.

2-3-6 “As-Built” Drawings

The Contractor shall neatly and professionally prepare as-built drawings for all work completed, on reproducible copies of the drawings and on electronic diskette in a program stipulated by the Engineer for all the trades Architectural, Structural, Mechanical, Electrical, Environmental, Landscape and other utilities and such other “As Built” drawings as are called for by the Specification and submit to the Engineer for approval, and shall provide additional drawings of those parts of the permanent work designed by the Contractor in accordance with sub - clause 7.2 of the Conditions of the Contract to clearly show details for such as electrical signal line and wiring connections, piping and instrumentation diagram, and other applicable drawings and sketches prepared for the work as required (being drawings which the Contractor or any subcontractor has to prepare for the purpose of the Works) and shall transmit the As- Built drawings to the Engineer on a continuous basis before completion of construction but in all cases prior to issuance of the certificate of completion of the Works.

The Contractor shall maintain on site one complete set of the Contract which shall be available to the Engineer at all times and upon which the Contractor shall record on a continuous basis all changes and field adjustments. On a continuous basis shall mean as the work is progressively accomplished in relation to each Drawing. As Built drawing progress prints shall be submitted to the Engineer for review and approval as each Contract drawing reached the 50 percent, 75 percent, and 100 percent completions stage.

As Built Drawings shall be considered as part of Contractor’s work effort. Failure to submit as- built drawings will be the cause for delay of the Engineer’s issuance of the Certificate of Completion.

2-3-7 Instruction and Maintenance Manuals

Where required under the Conditions of Contract and where required by the Specification, the Contractor shall provide four copies of instructions and maintenance manuals for equipment and installations. Manuals are to be in English and are to be properly bound in good quality hard covers and shall be submitted in accordance with Procedure Note 3: Instruction and Maintenance Manuals (included at the end of this section).

2-3-8 Completion

The works shall not be considered as complete for the purposes of the taking over under Clause 48 of the Contract until the “as built” drawings and instruction and maintenance manuals have been provided.

2-4 Bill Of Quantities

2-4-1 Measurement Procedures Generally

All Works shall be measured net and in accordance with of the General Conditions of Contract. All units of measurement shall be in the Metric System, unless specified otherwise.

2-4-2 Field Measurements

Field Measurements of quantities for monthly certificates and for final payment shall be made by the Contractor in the presence of the Engineer. Original copies of the field measurement notes, signed by the Contractor, will be retained by the Engineer.

If the Contractor fails to measure any Pay Items, the Engineer may, at his discretion, estimate quantities of such items for the monthly Payment Certificate or recommend that no payment be made for the Items not measured and quantities not computed until it is measured.

2-4-3 Manufactured Items

Whenever standard manufactured items are specified, such as fence wire, plates, rolled shapes, pipe conduit, etc. and these items are identified by gauge, unit weight, section dimensions, etc., such identifications shall be deemed to be Nominal weights or dimensions. Unless controlled by tolerances in cited specifications, manufacturing established by the industries involved may be accepted by the Engineer at the recommendation of the Concerned Authorities

2-4-4 Gage Designations

The term “gage” when referring to the size steel plate shall mean U.S. Standard Gage, except when referring to galvanized sheets used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches and metal cribbing, when “gage” shall be as specified in AASHTO M36 or AASHTO M167, and when referring to wire when “gage” shall be as specified in AASHTO M32.

2-4-5 Fittings and Accessories

When items are shown on the Drawings or specified as requiring miscellaneous fittings and accessories for which no separate measurement is provided, the Pay Item will be deemed to include for all such fittings and accessories.

2-4-6 Weight Measurements

All materials which are to be measured or proportioned by weight shall be on accurate and approved scales by competent and qualified personnel, at locations designated or approved by the Engineer.

Trucks used to haul material being paid for by weight shall be weighed empty each day at such times as the Engineer directs and each truck shall bear a plainly visible and legible identification mark.

2-4-7 Linear and Area Measurements

All items which are to be measured by linear meter, such as pipe culverts, guardrail, underdrains, etc., shall be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the Drawings.

Unless otherwise specified longitudinal measurements for area computations shall be made horizontally and no deductions shall be made for fixtures with an area less than one sq.m. Transverse measurements for area computations shall be the neat dimensions shown on the Drawings or as ordered by the Engineer.

2-4-8 Volume Measurements in Vehicles

Materials to be measured by volume in the hauling vehicle shall be hauled in approved type vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type approved by the Engineer provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to their level capacity and the Engineer may require loads to be leveled when the vehicles arrive at the point of delivery.

When requested by the Contractor and if approved by the Engineer material specified to be measured by the cu.m. may be weighed and such weights will be converted to cu.m. for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by mutual agreement between the Engineer and the Contractor if no agreement is obtained the factors will be determined by the Engineer and shall be accepted by the Contractor.

2-4-9 Earthwork Volume Measurements

The average end area method shall be used in computing quantities of earthworks except where the error exceeds plus or minus 5% when compared with the results obtained using the prismoidal formula, in which case the Engineer direct the use of the prismoidal formula. The Contractor shall request such direction before he submits his quantities for approval.

The quantities of excavation paid for under the Contract unit prices shall be limited to the lines shown on the Drawings and on approved cross sections. Excavation beyond lines shown on approved cross sections shall not be paid for unless approved by the Engineer. Excavation in excess of approved cross sections will be measured for payment only in the case of unstable or unsuitable materials ordered by the Engineer to be removed.

The Engineer will adjust the angle of slopes for cuts and fills as the Works proceed and make determinations of the appropriate slope angles following his evaluation of soil conditions in case there is a change in the type of the soil. The actual slopes of the cuts as constructed shall be measured and recorded by the Contractor. The Engineer will check these records and, if satisfactory, will approve the measurements as a basis for payment.

Within 60 days of the date of field survey, the Contractor shall submit to the Engineer for his approval plots of due original and final earthwork cross sections together with the area and volumetric earthwork computations. The Contractor's cross sections shall be on transparent

cross section sheets for print reproductions. All sheets shall have a title block and be of the size designated by the Engineer. On final approval of the Contractor's cross sections, the Contractor shall submit the original transparencies and 3 prints of each such transparency.

In case of any variations from the approved Drawings, the Contractor shall submit the original and 2 copies of the plotted cross sections and profiles and the notes and computations of his survey. The Contractor shall take cross sections at maximum 25m intervals along the centerline and at other locations if directed by the Engineer. Upon mutual agreement between the Engineer and the Contractor, the Contractor may submit cross sections intermediate to these locations. The Engineer will indicate, on one copy, his approval of the proposed lines of the Works or his revisions thereto and return such copy to the Contractor. The Contractor shall resubmit for approval any cross sections the Engineer may have revised.

The Contractor may, as an alternate method of earthwork computation, request approval to use an electronic computer. Such request shall include details of the computer hardware, the earthwork software programs, the input and output, and a complete summary of the methods and procedures to be used. The Contractor may use an electronic computer for computations, only if approved, and continuance of such approval is contingent upon satisfactory results being achieved. If results are not as represented or are otherwise deemed unsatisfactory, the Contractor shall recompute the earthwork quantities by the cross section method.

2-4-10 Ordering Materials

The quantities stated in the Bills of Quantities are not to be used for ordering materials.

2-4-11 Shop Drawings

- A. Submit newly prepared information, drawn to accurate scale. Do not reproduce Contract Documents or copy standard printed information as the basis of Shop Drawings.
1. Include the following information on Shop Drawings :
 - i) Dimensions
 - ii) Identifications of products and materials included
 - iii) Compliance with specified standards
 - iv) Notation of coordination requirements
 - v) Notation of dimensions established by the field measurement.
 2. Submit Coordination drawings where required for integration of different construction elements. Show construction sequences and relationship of separate components where necessary to avoid conflicts in utilisation of the space available.
 3. Highlight, encircle or otherwise indicate deviations from the Contract Documents on the Shop Drawings.
 4. Do not permit Shop Drawings copies without an appropriate final stamp or other marking indicating the action taken by the Engineer to be used in connection with construction.
 5. Initial Submittal: Submit copy and one reproducible Engineers review, the reproducible print will be returned.
 6. Final Submittal : submit 4 copies and one reproducible copy.

2-5 Procedure Note 1

2-5-1 Submittals For Shop Drawings

2-5-1-1 Shop Drawings

- A. Submit newly prepared information, drawn to accurate scale. Do not reproduce Contract Documents or copy standard printed information as the basis of Shop Drawings.
1. Include the following information on Shop Drawings :
 - i) Dimensions
 - ii) Identifications of products and materials included
 - iii) Compliance with specified standards
 - iv) Notation of co - ordination requirements
 - v) Notation of dimensions established by the field measurement.
 2. Submit Co - ordination drawings where required for integration of different construction elements. Show construction sequences and relationship of separate components where necessary to avoid conflicts in utilization of the space available.
 3. Highlight, encircle or otherwise indicate deviations from the Contract Documents on the Shop Drawings.
 4. Do not permit Shop Drawings copies without an appropriate final stamp or other marking indicating the action taken by the Engineer to be used in connection with construction.
 5. Initial Submittal: Submit copy and one reproducible Engineers review, the reproducible print will be returned.
 6. Final Submittal : submit 4 copies and one reproducible copy.

2-6 Procedure Note 2

2-6-1 Submittals For Product Data

2-6-1-1 Product Data

- A. Collect Product Data into a single submittal for each element of construction or system. Mark each copy to show which choices and options are applicable to the Project.
1. Where Product Data have been printed to include information on several similar products, some of which are not required for use on the Project, or are not included in this submittal, mark copies to clearly indicate which information is applicable.
 2. Where Product Data must be specially prepared for required products, materials or systems, because standard printed data are not suitable for use, submit as Shop Drawings not Product Data.
 3. Include the following information in Product Data :
 - i. Manufacturer's printed recommendations
 - ii. Compliance with recognized trade association standards
 - iii. Compliance with recognized testing agency standards

- iv. Application of testing agency labels and seals
 - v. Notation of dimensions verified by field measurement
 - vi. Notation of co - ordination requirements.
4. Do not submit Product Data until compliance with requirements of the Contract Documents has been confirmed.
 5. Submittals : Submit 2 copies of each required Product Data submittal; submit 2 additional copies where copies are required for maintenance manuals. The Engineer will retain one copy, and will return the other marked with the action taken and corrections or modifications required. Unless the Engineer observes non-compliance with provisions of the Contract Documents, the submittal may serve as the final submittal.
 6. Distribution : Furnish copies of final Product Data submittal to manufacturers, suppliers, fabricators, installers, governing authorities and others as required for performance of the construction activities. Show distribution on transmittal forms
 - i. Do not proceed with installation of materials, products and systems until a copy of Product Data applicable to the installers, governing authorities and others as required for performance of the construction activities. Show distribution on transmittal forms.
 - ii. Do not permit use of unmarked copies of Product Data in Connection with construction.

2-7 Procedure Note 3

2-7-1 Instruction And Maintenance Manuals

2-7-1-1 Summary

- A. This Procedure Note specifies administrative and procedural requirements for instruction and maintenance manuals including the following :
 1. Preparation and submittal of instruction of operating and maintenance manuals for building operation systems or equipment.
 2. Preparation and submittal of instruction manuals covering the care, preservation and maintenance of architectural products and finishes.
 3. Instruction of the Employer's operating personnel in operation and maintenance of building systems and equipment.
- B. Special operating and maintenance data requirements for specific pieces of equipment or building operating systems are included in the appropriate Sections of Divisions - 2 through 16.

2-7-1-2 Quality Assurance

- A. Maintenance Manual Preparation: In Preparation of Maintenance Manuals, use personnel thoroughly trained and experienced in operation and maintenance of the equipment or system involved.
 1. Where written instructions are required, use personnel skilled in technical writing to the extent necessary for communication of essential data.
 2. Where Drawings or diagrams are required, use draftsmen capable of preparing Drawings clearly in an understandable format.

- B. Instruction for the Owner's Personnel : For instruction of the Employer's operating and maintenance personnel, use experienced instructors thoroughly trained and experienced in the operation and maintenance of the building equipment or system involved.

2-7-1-3 Submittals

- A. Submittals Schedule : Comply with the following schedule for submittal of operating and maintenance manuals.
1. Before Substantial Completion, when each installation that requires submittal of operating and maintenance manuals is nominally complete, submit two draft copies of each manual to the Engineer for review. Include a complete index or table contents of each manual. The Engineer will return one copy of the draft with comments within thirty days of receipt.
 2. Submit one copy of data in final form at least thirty days before final of receipt of the Engineer's comments. inspection. This copy will be returned within thirty days after final inspection, with comments.
 3. After final inspection make corrections or modifications to comply with the Engineer's comments. Submit the specified number of copies of each approved manual to the Engineer within fifteen days of receipt of the Engineer's comments.
- B. Form of Submittal : Prepare operating and maintenance manuals in the form of an instructional manual for use by the Employer's operating personnel. Organise into suitable sets of manageable size. Where possible, assemble instructions for similar equipment's into a single binder.
1. Binder's : for each manual, provide heavy - duty, commercial quality, durable 3 - ring vinyl covered loose-leaf binder, in thickness necessary to accommodate contents, sized to receive 8 ½" by 11" paper. Provide a clear plastic sleeve on the spine, to hold labels describing the contents. Provide pockets in the covers to receive folded sheets.
 - i. Where two or more binders are necessary to accommodate data, correlate data in each binder into related groupings in accordance with the Project Manual table of contents. Cross- reference other binders where necessary to provide essential information for proper operation or maintenance of the piece of equipment or system.
 - ii. Identify each binder on the front and spine, with the typed or printed title " OPERATION AND MAINTENANCE MANUAL" Project title or name, and subject matter covered. Indicate the volume number for multiple volume sets of manuals.
 2. Dividers : Provide heavy paper dividers with celluloid covered tabs for each separate Section. Mark each tab to indicate contents. Provide a typed description of the product and major parts of equipment included in the Section on each divider.
 3. Protective Plastic Jackets : Provide protective transparent plastic jackets designed to enclose diagnostic software for computerized electronic equipment.
 4. Text Material : Where written material is required as part of the manual use the manufacturer's standard printed material, or if it is not available, specially, prepared data, neatly typewritten, on 8-1/2 " by 11" , 20 pound white bond paper.
 5. Drawings : Where drawings or diagrams are required as part of the manual, provide reinforced punched binder tabs on the drawings and bind in with the text.

- i. Where oversize drawings are necessary, fold the drawings to the same size as the text pages and as a foldout.
- ii. If drawings are too large to be used practically as a fold out, place the drawing, neatly folded, in the front or rear pocket of the binder. Insert a typewritten page indicating the drawing title, description of contents and drawing location at the appropriate location in the manual.

2-7-1-4 Manual Content

- A. In each manual include information specified in the individual Specification Section, and the following information for each major component of building equipment and its controls.
 1. General system or equipment description
 2. Design factors and assumptions
 3. Copies of applicable Shop Drawings and Product data
 4. System or equipment identification, including :
 - i. Name of manufacturer
 - ii. Model number
 - iii. Serial number of each component
 5. Operating instructions
 6. Emergency instructions
 7. Wiring diagrams
 8. Inspection and test procedures
 9. Maintenance procedures and schedules
 10. Precautions against improper use and maintenance
 11. Copies of warranties
 12. Repair instructions including spare parts listing
 13. Sources of required maintenance materials and related services
 14. Manual Index.
- B. Organize each manual into separate Sections for each piece of related equipment. As a minimum each manual shall contain a title page, a table of contents, copies of product Data, supplemented by drawings and written text, and copies of each warranty, bond and service Contract issued.
 1. Title Page : Provide a title page in a transparent plastic envelope as the first sheet of each manual . Provide the following information.
 - i. Subject matter covered by the manual
 - ii. Name and address of the Project
 - iii. Date of submittal
 - iv. Name, address, and telephone number of the Employer
 - v. Name and address of the Employer
 - vi. Cross reference to related systems in other operating and maintenance manuals.
 2. Table of Contents : After the Title Page, include a typewritten table of contents for each volume, arranged systematically according to the Project Manual format. Include a list of each product included, identified by the product name or other appropriate identifying symbol and indexed to the content of the volume.
 - i. Where more than one volume is required to accommodate data for a particular system, provide a comprehensive table of contents for all volumes in each volume of the set.

3. General Information : Provide a general information Section immediately following the Table of Contents, listing each product included in the manual, identified by product name. Under each product, list the name, address, and the maintenance contractor. Clearly delineate the extent of responsibility of each of these entities. In addition, list a local source for replacement parts and equipment.
4. Product Data : Where manufacturer's standard printed data is included in the manuals, include only sheets that are pertinent to the part or product installed. Mark each sheet to identify each part or product included in the installation. Where more than one item in a tabular format is included, identify each item, using appropriate references from the Contract Documents. Identify data that is applicable to the installation and delete references to information that is not applicable.
5. Written Text : Where manufacturer's standard printed data is not available, and information is necessary for proper operation and maintenance of equipment or systems, or it is necessary to provide additional information to supplement data included in the manual, prepare written text to provide necessary information. Organize the text in a consistent format under separate headings for different procedures. Where necessary, provide a logical sequence of instruction for each operating or maintenance procedure.
6. Drawings : Provide specially prepared drawings where necessary to supplement manufacturer's printed data to illustrate the relationship of component parts of equipment or systems, or to
7. Provide Control or flow diagrams. Co - ordinate these drawings with information contained in Project record Drawings to assure correct illustration of the completed installation.
 - i. Do not use original Project Record Documents as part of the Operating and Maintenance Manuals.
8. Warranties, Bonds and Service Contracts : Provide a copy of each warranty, bond or service contract in the appropriate manual for the information of the Owner's operating personnel. Provide written data outlining procedures to be followed in the event product failure. List circumstances and conditions that would affect validity of the warranty or bond.

2-7-1-5 Material And Finishes Maintenance Manual

- A. Submit four copies of each manual , in final form on material and finishes to the Engineer for distribution. Provide one section for architectural products, including applied materials and finishes, and a second for products designed for moisture protection and products exposed to the weather.
 1. Refer to individual Specification Sections for additional requirements on care and maintenance of materials and finishes.
- B. Architectural Products: Provide manufacturer's data and instructions on care maintenance of architectural products
 1. Manufacturer's Data : Provide complete information on architectural products, including the following as applicable
 - i. Manufacturer's catalogue number
 - ii. Size
 - iii. Material composition
 - iv. Color

- v. Texture
 - vi. Reordering information for specially manufactured products.
- 2. Care and Maintenance Instructions : Provide information on care and maintenance, including manufacturer's recommendation for types of cleaning agents to be used and methods of cleaning. Provide information regarding cleaning agents and methods that could prove detrimental to the product. Include manufacturer's recommended schedule for cleaning and maintenance.
- C. Moisture - Protection and Weather - Exposed Products : Provide complete manufacturer's data with instructions on inspection, maintenance and repair of products exposed to the weather or designed for moisture - protection purposes.
 - 1. Manufacturer's Data : Provide manufacturer's data giving detailed information, including the following, as applicable :
 - i. Applicable standards
 - ii. Chemical composition
 - iii. Installation details
 - iv. Inspection procedures
 - v. Maintenance information
 - vi. Repair procedures
- D. Schedule : Provide complete information in the materials and finished manual on products as directed by the Engineer.

2-7-1-6 Equipment And Systems Maintenance Manual

- A. Submit four copies of each completed manual on equipment and systems, in final form, to the Engineer for distribution. Provide separate manuals for each unit of equipment, each operating system, and each electric and electronic systems.
 - 1. Refer to Specification Sections for additional requirements on operating and maintenance of the various pieces of equipment and operating systems
- B. Equipment and Systems : Provide the following information for each piece of equipment, each building operating system, and each electric or electronic system.
 - 1. Description : Provide a complete description of each unit and related component parts, including the following :
 - i. Equipment or system function
 - ii. Operating characteristics
 - iii. Limiting conditions
 - iv. Performance curves
 - v. Engineering data and tests
 - vi. Complete nomenclature and number of replacement parts.
 - 2. Manufacturer's Information : For each manufacturer of a component part or piece of equipment provide the following:
 - i. Printed operating and maintenance instructions
 - ii. Assembly drawings and diagrams required for maintenance
 - iii. List of items recommended to be stocked as spare parts.
 - 3. Maintenance Procedures : Provide information detailing essential maintenance procedures, including the following :
 - i. Routine operations
 - ii. Trouble - shooting guide
 - iii. Disassembly, repair and reassembly
 - iv. Alignment, adjusting and checking

4. Operating Procedures : Provide information on equipment and system operating procedures, including the following :
 - i. Start - up procedures
 - ii. Equipment or system break - in
 - iii. Routine and normal operating instructions
 - iv. regulation and control procedures
 - v. Instructions on stopping
 - vi. Shut - Down and emergency instructions
 - vii. Summer and winter operating instructions
 - viii. Required sequences for electric or electronics systems
 - ix. Special operating instructions.
5. Servicing Schedule. Provide a schedule of routine servicing and lubrication requirements, including a list of required lubricants for equipment with moving parts.
6. Controls : Provide a description of the sequence of operation and as - installed control diagrams by the control manufacturer for systems requiring controls.
7. Co-ordination Drawings : Provide each Contractor's co - ordination drawings.
 - i. Provide as - installed color - coded piping diagrams, where required for identification.
8. Valve Tags : Provide charts of valve tag numbers, with the location and function of each valve.
9. Circuit Directories : For electric and electronic systems, provide complete circuit directories of panelboards, including the following :
 - i. Electric service
 - ii. Controls
 - iii. Communication.
- C. Schedule : Provide complete information in the equipment and systems manual on products specified as requested by the Engineer.

2-7-1-7 Instructions Of The Employer's Personnel

- A. Prior to final inspection, instruct the Employer's personnel in operation, adjustment and maintenance of products, equipment and systems. Provide instruction at mutually agreed upon times.
 1. For equipment that requires seasonal operation, provide similar instructions during other seasons.
 2. Use operation and maintenance manuals for each piece of equipment or system as the basis of instruction. Review contents in detail to explain all aspects of operation and maintenance.

3- MANAGEMENT PROCEDURES

3-1 Commencement, Program And Progress

3-1-1 Commencement

After receipt of the Order to Commence the Contractor shall inform the Engineer's Representative at least 7 days in advance, of the proposed date for commencing work on Site.

3-1-2 Co-Ordination

The Contractor shall co-ordinate the construction activities included therein to assure efficient and orderly installation of each Part of the works. Coordinate construction operations included under differing sections of the Specifications that are depended upon each other for proper installation connection and operation.

1. Where installation of one part of the work is dependent on the installation of the components either before or after its own installation schedule construction activities in the sequence required to obtain the best results.
2. Where availability of space is limited restricted by access or security co-ordinate installation of the different components to assure maximum accessibility at desired times for required maintenance service and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

3-1-3 Program

The Contractor shall provide for the Engineer's review in accordance with Conditions of Contract a computer-based program in critical path network (CPN) form, showing at least the following information:

- (a) Contract milestones (Engineer's Notice to commence, Commencement Date, date for completion of Sections of the Works, date for completion of the whole of the Works etc.)
- (b) Duration Of each construction activity in working days
- (c) Earliest/latest start and completion dates for each construction activity
- (d) Free float time for each activity
- (e) Total float time for each activity
- (f) Cost of each activity as per contract rates
- (g) Duration and earliest/latest dates for procurement of materials and plant
- (h) Duration and earliest/latest dates for activities to be performed by subcontractors
- (i) Number of working days per week and list of holidays
- (j) Number of working shifts per day for each construction activity
- (k) Activities for temporary works to be supplied and constructed and the dates for supply construction and removal
- (l) Dates for supply by the engineer of drawings and other information in accordance with conditions of contract clauses 6 and 7
- (m) Dates for submission by the Contractor of shop drawings samples and the like and dates for approval by the Project Manager/Engineer in accordance with Conditions of Contract sub clauses 7.2 and 7.3

- (n) Dates and times for work to be performed by other Contractors or for materials and Plant to be supplied by the Employer
- (o) Duration and earliest/latest dates for testing and commissioning plant and engineering installations
- (p) Bar chart showing earliest dates and total float of activities

3-1-4 Guidance

The Contractor shall abide by the following :

- (a) The Engineer will guide the contractor in the determination of the level of detail to be included in the CPN
- (b) Construction activities will not be scheduled to exceed twenty-five (25) working days without the approval of the Engineer
- (c) One day will be the smallest time unit used

3-1-5 Hardware

The computer hardware shall be IBM compatible

3-1-6 Computer Software

Project management software shall be of the professional high-end type (e.g. "Open Plan " "Primavera" or of similar capabilities) and it shall be to the approval of the Engineer. Contractor is to identify and submit details in his tender of his proposed software program.

3-1-7 Resource Schedules

The computer program used for preparing the program shall also be used for preparation of resource schedules to be submitted to the Engineer with the program. The resource schedules shall show at least the following information:

- (a) quantity of materials to be used for each activity
- (b) numbers and classes of workmen to be employed on the Site for each activity
- (c) numbers and classes of equipment to be used for each activity
- (d) histogram for workmen by class and overall classes
- (e) histogram for equipment by class and overall classes.

3-1-8 Cash Flow Estimate

The computer program used for preparing the program shall also be used to prepare the cash flow estimate to be submitted by the Contractor in accordance with Conditions of Contract sub-clause 14.3.

3-1-9 Monitoring

The Contractor shall monitor progress of the works and the supply of resources and cash flow compared with the program schedules and estimate, update the program with actual progress data monthly and shall revise the program schedules and estimate as required by Conditions of

Contract Clause 14. Copies of revised programs etc. and notices of actual and forecast delays and shortfalls shall be regularly given to the Engineer.

3-1-10 Computer Program

The Contractor shall provide the Engineer with a copy on the computer diskette of the Target updated and new Target programs, schedules and estimates.

3-1-11 Materials Procurement Schedules

The Contractor shall submit within 98 days after the date of the Letter of Acceptance a comprehensive Materials Procurement Schedule, tied with the Program of Works to include submission approval order and delivery stages status. The Contractor shall update this schedule monthly. Copy of revised schedule shall be regularly gives to the Engineer.

3-2 Records And Measurements

3-2-1 Labor Record

The Contractor shall provide each week a record showing the number and description of workmen employed each day on the Works including those employed by subcontractors.

3-2-2 Materials And Plant Record

The Contractor shall provide each week a record showing the quantity and description of all materials and plant delivered to the Site complete with copies of delivery notes.

3-2-3 Equipment Record

The Contractor shall provide each week a record showing the number, type and capacity of all Contractors Equipment, excluding hand tools daily employed on the Works.

3-2-4 Daily Work Record

The Contractor shall provide each day a record showing activities performed and locations in which work has been carried out and any other matter requested by the Engineer's Representative.

3-2-5 Monthly Report

The Contractor shall provide monthly reports which summarize the daily and weekly reports and deliver to the Engineer's Representative not later than one week following the end of each month.

3-2-6 Wages Books And Time Sheets

The Contractor shall keep accurate and proper wage books and time sheets showing wages paid to and time worked by workmen and, when required, produce such wage books and time sheets for inspection by the Engineer's Representative.

3-2-7 Climatic Conditions

The Contractor shall measure and keep an accurate daily record of and submit to the Engineer's Representative at the end of each week.

Air temperatures: maximum and minimum

Humidity

Rainfall : total in mm and hours

3-2-8 Special Records

In the event of delays for which an extension of time for completion is sought under Clause 44 or in the event of any claim for costs, the Contractor shall keep such special records of the circumstances as the Engineer's Representative may require, and submit copies regularly for his inspection.

3-2-9 Photographs

The Contractor shall provide progress photographs taken from approved stations but not less than 36 (thirty six) at monthly intervals and submit the negative and 3 prints not less than 16 cm x 20 cm of each negative.

3-3 Site Administration

3-3-1 Engineer's Site Meetings

The Engineer's Representative will hold site meetings once a month or more frequently if he deems necessary for the efficient management of the Works and he will distribute minutes. Attend all such meetings and secure the attendance of subcontractors and others if requested by the Engineer's Representative.

3-3-2 Contractor's Site Meetings

The Contractor shall hold such meetings as are necessary for co-ordination of subcontractors and review of progress.

3-3-3 Co-Ordination Of Subcontractors Etc.

The Contractor shall co-ordinate the work of all trades and subcontractors so as to avoid delay and disruption or abortive work. The Contractor shall provide all drawings, dimensions and other information required for the proper execution of subcontract works and of associated builder's work and accept responsibility for the accuracy and fitness of subcontract works.

3-3-4 Quality Control

The contractor shall prepare and submit for approval by the Engineer a proposal for the Quality Control Management of the project. This proposal shall incorporate the requirements set out in B S 5750 or its equivalent and shall be incorporated into the Procedure Manual and will form an integral part of the contractors management of the project. The proposal shall include, but not be restricted to:

- The provision and maintenance of a quality control program throughout the project,
- Inspection and testing of products, both on and off site, by independent professional inspection and testing companies,
- Provision of inspection and testing equipment,
- Verification of affidavits and certificates that selected materials meet the specified standards,
- The maintenance of quality control documentation in accordance with the various procedures identified in these documents.

3-3-5 Procedures Manual

The Contractor shall prepare and agree with the Engineer a Procedure Manual for the administration of the Project.

3-4 Completion

3-4-1 Notice Of Completion

The Contractor shall give the Engineer's Representative at least four weeks notice of the anticipated date of substantial completion of the whole or any part of the Works.

3-4-2 Making Good Defects

The Contractor shall make arrangements with the Employer and give reasonable notice of the dates for access to the various parts of the Works for the purpose of making good defects and shall inform the Engineer's Representative of the dates and when remedial works to the various parts of the Works are completed.

4- QUALITY STANDARDS AND CONTROL

4-1 Generally

4-1-1 Good Practice

Where and to the extent that materials products and workmanship are not fully specified they are to be of a standard appropriate to the Works and suitable for the purposes stated in or reasonably to be inferred from the Contract Documents, and in accordance with good building practice including the relevant provisions of current standards regulations etc.

4-2 Setting Out And Accuracy

4-2-1 Site Survey

Before commencing Works on Site the Contractor shall carry out a topographical survey of the Site in conjunction with or as instructed by the Engineer's Representative or of such parts or the Site as the Engineer's Representative may direct to record the Site limits, dimensions, ground levels obstructions and other features and to establish base lines and points for future setting out and to record the basis for remeasurement of excavation and earthwork, where applicable.

4-2-2 General Setting Out

Shall be performed using methods and measuring instruments described in BS 5606, Section 5 and within the permissible deviations described in Table 4 in relation to the instruments being used.

Details of methods and equipment to be used in setting out the Works shall be submitted to the Engineer's Representative.

The Contractor shall inform the Engineer's Representative when setting out is complete and before Commencing construction and shall provide instruments and assistance for checking the setting out if required by the Engineer's Representative.

4-2-3 Setting Out Utility Works

Shall be as shown on the Drawings or as instructed on Site. Stake-out shall be revised if, in the opinion of the Engineer's Representative, modification of line or grade is advisable.

4-2-4 Setting Out Civil Work

Shall be as shown on Drawings or as instructed on site.

4-2-5 Record Drawings

The Contractor shall record details of all grid lines, existing ground levels, setting-out stations, bench marks and profiles on the site setting-out drawing; retain on the Site throughout the duration of the Contract and hand to the Engineer's Representative on completion.

4-2-6 All Dimensions And Levels

Both on the Drawings and the Site, shall be checked particularly the correlation between components and the work in place. Materials and components shall not be ordered or work carried out until any discrepancies have been resolved with the Engineer.

4-2-7 Appearance And Fit

The Works shall be constructed to higher levels of accuracy than those specified where necessary to achieve a satisfactory appearance and to ensure that materials, elements and components of the building fit together as designed. Wherever the accuracy, fit or appearance of the work is likely to be critical or difficult to achieve, the Contractor shall obtain the Engineer's approval of proposals or of the partially finished work as early as possible

4-2-8 Non-Compliance

Work which fails to meet the specified levels of accuracy must not be rectified without approval. Submit proposals for such rectification or removal and replacement and meet all costs arising, including effects on other work.

4-3 Materials

4-3-1 Products

Are to be new unless otherwise specified and are to be handled stored and fixed with care to ensure they are not damaged when incorporated in the work. Selection of products shall be in accordance with Procedure Note 4 : Product Selection (included at the End of this Section).

4-3-2 Product List Schedule

The Contractor shall, before placing any purchase order for any materials intended for incorporation in the Works, submit for approval a product list schedule giving a complete description of all such materials, names of the firms from whom he proposes to purchase them and copies of all test reports verifying conformity with the provisions of the Specifications. Materials shall not be ordered without the approval of the Engineer. When directed by the Engineer or otherwise specified, the Contractor shall submit suitable samples for approval.

4-3-3 Standards

For products and materials specified to a national standard, such as BS or ASTM, certificates of compliance are to be obtained from manufacturers when requested by the Engineer or the Engineer's Representative.

4-3-4 Single Sources

Where a choice of manufacturer or source or supply is allowed for any particular product or material, the whole quantity required to complete the work must be of the same type, manufacture and source. Written evidence of sources of supply are to be provided when

requested by the Engineer or the Engineer's Representative and sources are not to be changed without approval .

4-3-5 Checking Compliance Of Products And Materials

The Contractor shall check all delivery tickets, labels, identification marks and where appropriate, the goods themselves to ensure that all products comply with the Specification. Where different types of any product are specified, he shall ensure that the correct type is being used in each location. In particular, the following shall be checked:

- Sources types, qualities, finishes and colors are correct, and match any approved samples
- Accessories and fixings which should be supplied with the goods have been supplied
- Sizes and dimensions are correct
- Goods are clean, undamaged and in good condition, with intact protective coverings and unbroken seals
- Materials which have a limited shelf life are not out of date.

4-3-6 Storage Of Materials

Materials shall be stored as to assure the preservation of their quality and suitability for the Works. Stored materials, approved before storage, may again be inspected prior to their use in the Works. Stored materials shall be located so as to facilitate their prompt inspection.

Materials shall not be stored in the ROW except where permitted by the Engineer. Stockpiling of aggregate material within the ROW shall also be confined to such authorized areas.

Where materials are stockpiled on Government or private property, such sites shall be abandoned immediately upon utilization of all stockpiled materials and the natural surface shall be restored as far as practicable to the original condition by the Contractor and to the satisfaction of the Engineer.

4-3-7 Protection Of Products And Materials

The Contractor shall:

- Prevent over-stressing and any other type of physical damage.
- Keep clean and free from contamination and staining.
- Keep dry and in a suitably low humidity atmosphere to prevent premature setting moisture movement and similar defects. Where appropriate allow free air movement around and between stored components.
- Prevent excessively high or low temperatures and rapid changes of temperature in the material.
- Protect adequately from rain, frost, sun and other elements as appropriate.
- Keep different types and grades of materials separately and adequately identified.
- So far as possible, keep materials in their original wrappings, packings or containers, with unbroken seals, until immediately before they are used.

4-3-8 Materials Supplied By Employer

The Contractor shall be responsible for all materials furnished by the Employer and shall make good any shortages or deficiencies, from any cause whatsoever, or any damage which may occur, after delivery of such materials.

4-3-9 Local Material Sources

When material sources are not designated on the Drawings or in other documents, the Contractor shall be responsible for locating and providing suitable materials from approved sources.

Any information provided in the tender documents about sources of local materials is considered as a guideline only and does not relieve the Contractor of his responsibility in respect of investigation and supply of suitable materials as specified.

Materials, regardless of their source, shall not be incorporated in the Works until approved by the Engineer.

4-4 Contractor's Plant And Equipment

4-4-1 Plant And Equipment

Used on the Works shall be of sufficient size and in such mechanical condition as to meet the requirements of the Specification and shall be available for use when required by the Engineer. The Engineer may order removal and replacement of unsatisfactory plant or equipment.

4-4-2 Plant And Equipment Of A Particular Size or Type

Wherever Plant And Equipment Of A Particular Size or type is specified, the Contractor may request permission to use an alternative type in place of that specified. In such cases, the Contractor shall furnish evidence to the Project Manager/Engineer, before approval is given, that the production of the plant or equipment proposed is at least equal to that of the specified type.

4-4-3 Contractor's Schedule Of Plant And Equipment

The Contractor shall submit together with his Tender, a detailed schedule of the numbers and types of plant and equipment which he proposes to utilize on Site to carry out the Works. The schedule shall contain full details for each item, including type, manufacturer, model, identification number, year of manufacture, number of years in use, and, for all new and previously used items, the manufacturer's brochures, catalogs and specifications.

4-4-4 Provision And Use Of Plant And Equipment

The Contractor shall furnish all plant and equipment listed in his Schedule and necessary for construction of each phase of the Works. Such plant and equipment shall be delivered to the Site, inspected, and approved by the Engineer prior to commencement of the particular phase of the Works for which it is intended. Any plant or equipment, or part thereof, which becomes

excessively worn or defective shall be promptly repaired or replaced, as required by the Engineer.

4-4-5 Removal From Site

The Contractor shall not remove from the Site any approved plant or equipment without the permission of the Engineer.

4-5 Workmanship

4-5-1 Work

Work is to be carried out by or under the close supervision of experienced tradesmen skilled in the particular type of work.

4-5-2 Manufacturer's Recommendations

Products shall be handled, stored, prepared and used in accordance with manufacturer recommendations. The Contractor shall inform the Engineer's Representative if these conflict with any other specified requirement and submit copies of manufacturer's recommendations to the Engineer's Representative when requested.

4-5-3 Suitability Of Previous Work And Conditions

Before starting each new type or section of work the Contractor shall ensure that:

- Previous related work is appropriately complete, in accordance with the project documents, to a suitable standard and in a suitable condition to receive the new work.

4-5-4 Defects In Existing Work

The Contractor shall report to the Engineer Representative if any existing work is defective and obtain his instructions before proceeding with new work which may cover up the defective work or which may be adversely affected by the defective work.

4-5-5 Rectification Of Defective Work

If any part of the work is known or is suspected to be not in accordance with the Contract, the Contractor shall submit proposals to the Engineer for opening up, inspecting, testing and rectification and carry out the Engineer's instructions in relation thereto, including, where so instructed, removal and reconstruction.

4-5-6 Warranties

The Contractor shall:

- Comply with specific requirements for warranties for work, products and installations that are required to be warranted in the specifications,

- Ensure that all warranties shall commence on the date of completion and are transferable to the employer upon completion of the defects liability period, if the specific period of warranty exceeds this date.
- Ensure that the following additional requirements are accommodated in the warranties :
 - a) Related damage and losses when correcting warranted work that has failed, replace other work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted work.
 - b) Re-instatement of warranty : when work covered a warranty has failed and been corrected by replacement or rebuilding reinstate warranty by written endorsement the reinstalled warranty shall be equal to the original warranty with an equitable adjustment for depreciation.
 - c) Replacement cost : upon determination that the work covered by a warranty has failed, replace or rebuild the work to an acceptable condition complying with the requirements of the Contract Documents. The Contractor shall be responsible for the cost of replacing a rebuilding defective work regardless of whether the Employer has benefited from use of the Work through a portion of its anticipated useful service life.
- Submit written warranties for approval to the Engineer prior to date certified for completion or completion of parts as may be designated.
- At final completion, compile four copies of each required warranty and bind in loose leaf binders in a clear and logical manner.

4-5-7 Warranties Employer Recourse

Written warranties made to the Employer are in addition to implied warranties, and shall not limit the duties, obligations, rights and remedies otherwise available under law, nor shall warranty periods be interpreted as limitations on time in which the Employer can enforce other duties, obligations rights, or remedies.

- Rejection of warranties: The Employer reserves the right to reject warranties to limit selections of products with warranties not in conflict with requirements of the contract documents.

4-6 Samples And Approvals

4-6-1 Samples

Where approval of products or materials is specified, the Contractor shall submit samples or other evidence of suitability. Orders shall not be confirmed or materials used until approval has been obtained. Approved samples are to be retained on the Site for comparison with products and materials used in the Works and removed when no longer required. All materials being used will be subject to inspection, testing, or rejection at any time prior to such incorporation.

Where samples of finished work are specified the Contractor shall obtain approval of stated characteristics before proceeding with the Works and shall retain approved samples on the Site for comparison with the Works Samples which are not part of the finished works shall be removed when no longer required.

Shall be submitted in accordance with Procedure Note 5: Submittal of Samples (included at the end of this section).

4-6-2 Source Tests

All sources samples shall be taken by the Contractor in the presence of the Engineer, using approved sampling procedures. All source approval tests shall be performed under the supervision of the Engineer or, when so specified, by an independent laboratory approved by the Engineer and engaged by the Contractor.

After approval of any source of materials, the Contractor shall produce from such source only to the extent that materials produced are of substantially the same quality as the approved samples.

The Engineer will periodically order retesting of previously approved sources to verify that they continue to conform to the Specifications and may order retesting at the same or at different laboratory from the one performing the original approval tests. If retesting indicates that a previously approved source no longer conforms with the Specifications, the Contractor shall forthwith cease production from such source.

4-6-3 Approvals

Where and to the extent that products materials or work are specified to be approved, or the Engineer instructs or requires that they are to be approved, the same must be supplied and executed to comply with all other requirements and, in respect of the stated or implied characteristics, either to the express approval of the Engineer, or to match a sample expressly approved by the Engineer as a standard for the purpose.

Inspection or any other action by the Engineer must not be taken as approval of materials, products or work unless the Engineer so confirms in writing in express terms referring to:

- Date of inspection
- Part of the work inspected
- Respects or characteristics which are approved
- Extent and purpose of the approval
- Any associated conditions.

Approval, inspection or any other action by the Engineer shall not in any way relieve the Contractor from his responsibility for the suitability and fitness for purpose of materials, products or work.

Where untested and unaccepted materials have been used, without approval of the Engineer, such use shall be at the Contractor's risk.

4-7 Work At Completion

4-7-1 Clearing Etc.

The Contractor shall clear the Works of all rubbish and surplus materials consequent upon the execution of the work. Clearing is to be carried out using methods approved by the Engineer's Representative and is to be completed in accordance with Procedure Note 6 : Final Cleaning (included at the end of this section).

4-7-2 Temporary Markings

Coverings and protective wrappings shall be removed unless otherwise instructed by the Engineer's Representative.

4-7-3 Partial Possession By Employer

Where the Works are to be completed in sections, and any such section depends for its adequate functioning on work located elsewhere on the Site, such other work shall be completed in time to permit sectional completion as required.

4-7-4 Project Completion Procedures

The project completion shall be conducted in the manner prescribed in the Procedure Note 7: Project Completion (included at the end of this section).

4-8 Procedure Note 4

4-8-1 Product Selection

4-8-1-1 Product Selection

- A. General Product Requirements: Provide products that comply with the Contract Documents, that are undamaged and, unless otherwise indicated, unused at the time of installation
 - 1. Provide products complete with all accessories, trim, finish, safety guards and other devices and details needed for a complete installation and for the intended use and effect.
 - 2. Standard Products: where available, provide standard products of types that have been produced and used successfully in similar situations on other projects.
- B. Product Selection Procedures: Product selection is governed by the Contract Documents and governing regulations, not by previous Project experience. Procedures governing product selection include the following:
 - 1. Proprietary Specification Requirements: Where only a single product or manufacturer is named, provide the product indicated. No substitutions will be permitted.
 - 2. Semiproprietary Specification Requirements: where two or more products or manufacturers are named, provide one of the products indicated. No substitutions will be permitted.
 - a. Where products or manufacturers are specified by name, accompanied by the term "or equal" or "or approved equal" comply with the Contract Document provisions concerning "substitutions" to obtain approval for use of an unnamed product.
 - 3. Non - Proprietary Specifications: when the Specifications list products or manufacturers that are available and may be incorporated in the Work. but do not restrict the Contractor to use of these products only, the Contractor may propose any available product that complies with Contract requirements. Comply with

Contract Document provisions concerning "substitutions" to obtain approval for use of an unnamed product.

4. Descriptive Specification Requirements: where Specifications describe a product or assembly, listing exact characteristics required, with or without use of a brand or trade name, provide a product or assembly that provides the characteristics and otherwise complies with Contract requirements.
5. Performance Specification Requirements: where Specifications require compliance with performance requirements, provide products that comply with these requirements, and are recommended by the manufacturer for the application indicated. General overall performance of a product is implied where the product is specified for a specific application.
 - a. Manufacturer's recommendations may be contained in published product literature, or by the manufacturer's certification of performance.
6. Compliance with Standards, Codes and Regulations: where the Specifications only require compliance with an imposed code, standard or regulation, select a product that complies with the standards, codes or regulations specified.
7. Visual Matching: where Specifications require matching an established Sample, the Engineers decision will be final on whether a proposed product matches satisfactorily.
 - a. Where no product available within the specified category matches satisfactorily and also complies with other specified requirements, comply with provisions of the Contract Documents concerning "substitutions" for selection of a matching product in another product category, or for non - compliance with specified requirements.
8. Visual Selection: where specified product requirements include the phrase"..... as selected from manufacturer's standard colors, patterns, textures" or a similar phrase, select a product and manufacturer that complies with other specified requirements. The Engineer will select the color pattern and texture from the product line selected.

4-9 Procedure Note 5

4-9-1 Submittal Of Samples

4-9-1-1 Samples

Submit samples physically identical with the material or product proposed for use; submit full-size, fully fabricated samples, cured and finished in the manner specified.

1. Mount, display, or package samples in the manner specified to facilitate review of qualities indicated. Prepare samples to match the Engineer's sample where so indicated. Include the following information.
 - a. Generic description of the sample
 - b. Size limitations
 - c. Sample source
 - d. Product name or name of manufacturer
 - e. Compliance with recognized standards
 - f. Compliance with governing regulations
 - g. Availability
 - h. Delivery time.

2. Submit samples for review of kind, color, pattern, and texture, for a final check of these characteristics with other elements, and for a comparison of these characteristics between the final submittal and the actual component as delivered and installed.
 - a. Where variations in color, pattern, texture or other characteristics are inherent in the material or product represented by a sample, submit sets of multiple units of the sample (not less than 3 units), which show approximate limits of the variations.
 - b. Refer to other Specification sections for requirements for samples that illustrate workmanship, fabrication techniques, details of assembly, connections, operation and similar construction characteristics.
 - c. Refer to other Specification sections for samples to be returned to the Contractor for incorporation in the work, Such samples must be in an undamaged condition at time of use. On the transmittal form, indicate such special requests regarding disposition of sample submittals.
3. Preliminary Submittals: where samples are specified for selection of colour, pattern, texture or similar characteristics from a manufacturer's range of standard choices, submit a single, full set of available choices for the material or product.
 - a. Preliminary submittals will be reviewed and returned with the Engineers marking indicating selection and other action taken
4. Submittals: except for samples intended to illustrate assembly details, workmanship, fabrication techniques, connections, operation and other characteristics, submit sets of samples; one set will be returned marked with the action taken.
 - a. Maintain sets of samples, as returned by the Engineer, at the Project site, available for quality control comparisons throughout the course of construction activity.
 - b. Unless the Engineer observes non-compliance with provisions of the Contract Documents, the submittal may serve as the final submittal
 - c. Sample sets may be used to obtain final acceptance of the construction associated with each set.
5. Distribution of Samples: prepare and distribute additional set of samples to subcontractors, suppliers, fabricators, manufacturers, installers, governing authorities, and other as required for performance of the work. Show distribution on transmittal forms.
6. Field Samples specified in individual Specification sections are special types of samples. Comply with sample submittal requirements to the fullest possible. Process transmittal forms to provide a record of activity.

4-10 Procedure Note 6

4-10-1 Part 1 - Final Cleaning

4-10-1-1 Final Cleaning

- A. This procedure note specifies administrative and procedural requirements for final cleaning at completion.
 1. Special cleaning requirements for specific elements of the work are included in appropriate sections of Parts 2 to 10.
- B. General Project close-out requirements are included in Procedure Note 7: Project Completion.
- C. Environmental Requirements: Conduct cleaning and waste disposal operations in compliance with local laws and ordinances. Comply fully with government and local environmental and anti-pollution regulations.

4-10-2 Part 2-Products

4-10-2-1 Materials

- A. Cleaning Agents: Use cleaning materials and agents recommended by the manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property on that might damage finish surfaces.

4-10-3 Part 3 - Execution

4-10-3-1 Final Cleaning (where applicable)

- A. General. Provide final cleaning operations when indicated. Employ experienced workers or professional cleaners for final cleaning, at the discretion of the Engineer..
- B. Complete the following cleaning operations before requesting inspection for Final Certificate of Completion for the entire Project or a portion of the Project.
 - 1. Clean the Project site, yard and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste materials, litter and foreign substances. Sweep paved areas broom clean. Remove petrochemical spills, stains and other foreign deposit. Rake grounds that are neither planted nor paved, to a smooth even-textured surface.
 - 2. Remove tools, construction equipment, machinery and surplus material from the site.
 - 3. Clean exposed exterior and interior hard-surfaced finishes to a free condition, free of stains, films and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
 - 4. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes and similar spaces.
 - 5. Broom clean concrete floors in unoccupied spaces.
 - 6. Remove labels that are not permanent labels.
 - 7. Touch-up and otherwise repair and restore marred exposed finishes and surfaces. Replace finishes and surfaces that can not be satisfactorily repaired or restored, or that show evidence of repair or restoration. Do not paint over "UL" and similar labels, including mechanical and electrical name plate.
 - 8. Wipe surfaces of mechanical and electrical equipment, elevator equipment and similar equipment. Remove excess lubrication, paint and mortar droppings and other foreign substances.
 - 9. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
 - 10. Replace air disposable filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills. 1 Clean ducts, blowers, and coils if units were operated without filters during construction.
 - 11. Clean light fixtures, lamps, globes and reflectors to function with full efficiency. Replace burned out bulbs, and defective and noisy starters in fluorescent and mercury vapor fixtures.
 - 12. Leave the Project clean and ready for use.
- C. Removal of Protection: Remove temporary protection and facilities installed during construction to protect previously completed installations during the remainder of the construction period.

- D. Compliance: Comply with governing regulations and safety standards for cleaning operations. Remove waste materials from the site and dispose of in a lawful manner.
 - 1. Where extra materials of value remain after completion of associated construction have become the Employer's property, dispose of these materials as described.

4-11 Procedure Note 7

4-11-1 Part 1 - Project Completion

4-11-1-1 Summary

- A. This Section specifies administrative and procedural requirements for project completion including but not limited to:
 - 1. Inspection procedures
 - 2. Project record document submittal
 - 3. Operating and maintenance manual submittal
 - 4. Submittal of warranties
 - 5. Final cleaning.
- B. Close-out requirements for specific construction activities are included in the appropriate sections in Part-2 to Part-10.

4-11-1-2 Partial Completion

- A. Preliminary Procedures: before requesting inspection for taking over certificate of Final or Partial Completion, complete the following:
 - 1. Submit specified warranties, maintenance agreements, final certifications and similar documents.
 - 2. Obtain and submit releases enabling the Employer unrestricted use of the Work and access to services and utilities; include occupancy permits, operating certificates and similar releases.
 - 3. Deliver tools, spare parts, extra stock, and similar items.
 - 4. Make final change-over of permanent locks and transmit keys to the Employer. Advise the Employer's personnel of change-over in security provisions.
 - 5. Complete start-up testing of system, and instruction of the Employer's operating and maintenance personnel. Discontinue or change over and remove temporary facilities from the site, along with construction tools, mock-ups, and similar elements.

4-11-1-3 Final Completion

- A. Preliminary Procedures-. before requesting final inspection for certification of final acceptance complete the following. List exceptions in the request.
 - 1. Submit a certified copy of the Engineer's final inspection list of items to be completed or corrected, stating that each item has been completed or otherwise resolved for acceptance, and the list has been endorsed and dated by the Engineer.
 - 2. Submit final meter readings for utilities, a measured record of stored fuel, and similar data as of the date of substantial completion, or when the Owner took possession of and responsibility for corresponding elements of the Work.

3. Submit evidence of final, continuing insurance coverage complying with insurance requirements.
- B. Reinspection Procedure: The Engineer will reinspect the work upon receipt of notice that the work, including inspection list items from earlier inspections, has been completed, except items whose completion has been delayed because of circumstances acceptable to the Engineer.
 1. Upon completion of reinspection, the Engineer will prepare a certificate of final acceptance, or advise the Contractor or Work that is incomplete or of obligations that have not been fulfilled but are required for final acceptance.
 2. If necessary, reinspection will be repeated.

4-11-1-4 Record Document Submittals

- A. General: Do not use record documents for construction purposes; protect from deterioration and loss in a secure, fire-resistive location; provide access to record documents for the Engineer's reference during normal working hours.
- B. Record Drawings: Maintain a clean, undamaged set of blue or black line white-prints of Contract Drawings and Shop Drawings. Mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
 1. Mark record sets with red erasable pencil., use other colors to distinguish between variations in separate categories of the Work.
 2. Mark new information that is important to the Employer, but was not shown on Contract Drawings or Shop Drawings.
 3. Note related change order numbers where applicable.
 4. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set.
- C. Record Specifications: Maintain one complete copy of the Project Manual, including addenda, and one copy of other written construction documents such as Variations and modifications issued in printed form during construction. Mark these documents to show substantial variations in actual Work performed in comparison with the text of the Specifications and modifications. Give particular attention to substitutions, selection of options and similar information on elements that are concealed or cannot otherwise be readily discerned later by direct observation. Note related record drawing information and Product Data.
 1. Upon completion of the Work, submit record Specifications to the Engineer for the Employer's records.
- D. Record Product Data: Maintain one copy of each Product Data submittal. Mark these documents to show significant variations in actual Work performed in comparison with information submitted. Include variations in products delivered to the site, and from the manufacturer's installation instructions and recommendations. Give particular attention to concealed products and portions of the Work which cannot otherwise be readily discerned later by direct observation. Note related Variations and mark-up of record drawings and Specifications.
 1. Upon completion of mark-up, submit complete set of record Product Data to the Engineer for the Employer's records.

- E. Record Sample Submitted: Immediately prior to the date or dates of Substantial Completion, the Contractor will meet at the site with the Engineer and the Employer's personnel to determine which of the submitted samples that have been maintained during progress of the Work are to be transmitted to the Employer for record purposes. Comply with delivery to the Employer's Sample storage area.
- F. Miscellaneous Record Submittals.. Refer to other Specification Sections for requirements of miscellaneous record-keeping and submittals in connection with actual performance of the Work. Immediately prior to the date or dates of Substantial Completion, complete miscellaneous records and place in good order, properly identified and bound or filed, ready for continued use and reference. Submit to the Engineer for the Employer's records.

4-11-2 Part 2 - Execution

4-11-2-1 Close-Out Procedures (where applicable)

- A. Operating and Maintenance Instructions: Arrange for each installer of equipment that requires regular maintenance to meet with the Employer's personnel to provide instruction in proper operation and maintenance. If Installers are not experienced in procedures, provide instruction by manufacturer's representatives. Include a detailed review of the following items, as directed by the Engineer:
 - a. Maintenance manuals
 - b. Record documents
 - c. Spare parts and materials
 - d. Tools
 - e. Lubricants
 - f. Fuels
 - g. Identification systems
 - h. Control sequences
 - i. Hazards
 - j. Cleaning
 - k. Warranties and bonds
 - l. Maintenance agreements and similar continuing commitments.
- B. As part of instruction for operating equipment, demonstrate the following procedures:
 - a. Start-up
 - b. Shutdown
 - c. Emergency operations
 - d. Noise and vibration adjustments
 - e. Safety procedures
 - f. Economy and efficiency adjustments
 - g. Effective energy utilization.

5- TEMPORARY WORKS AND SERVICES

5-1 Generally

5-1-1 Locations

The Engineer's Representative's approval is to be obtained for the intended Temporary Works and services.

5-1-2 Standards And Details

Temporary Works are to be constructed to recognized standards and codes of practice so that they are fit for their purpose. Drawings and details of proposed Temporary Works are to be provided by the Contractor if requested by the Engineer.

5-1-3 Temporary Works

Temporary Works and services are to be maintained, altered and adapted and as necessary and cleared away on completion or when no longer required. Work disturbed is to be made good.

5-1-4 General

The Contractor shall provide all Temporary Works and services and Contractor's Equipment and tools required for the efficient and safe execution of the Works, including but not limited to:

- Temporary roads, hard standings, sleeper tracks and the like
- Temporary fences, gates and barriers
- Temporary offices, stores, messrooms, latrines and compounds
- Scaffold, ladders, hoists, cranes and the like
- Temporary screens, chutes, coverings, roofs and rainwater pipes for protection of the Works and personnel.
- Transport and vehicles on and off Site
- Fixed and movable mechanical plant and equipment
- Small tools
- Temporary water and power supplies and site lighting
- Temporary drainage.

5-2 Temporary Site Facilities

5-2-1 Roads

Permanent roads, hard standings and footpaths on the Site may be used provided they are adequately maintained and thoroughly cleaned and made good after use and left in unimpaired condition.

5-2-2 Diversions

The Contractor shall:

- (i) Provide temporary detour roads, and other facilities to divert traffic through or around any part of the Works or for maintenance of traffic in locations affected by his works that warrant such temporary works. Location, standard, width, construction and maintenance of detour routes shall be approved by the Engineer's Representative, ensuring at all times that the routes are signed, striped, maintained and furnished with all traffic control devices as shown, directed and/or needed.
- (ii) Submit designs and detailed working drawings of the proposed temporary works for approval by the Engineer prior to commencement of the works. The design live load for temporary bridges related to roads exposed to heavy vehicles shall not be less than the design live load for permanent bridges, or as directed by the Engineer,
- (iii) Where measure are taken for continuously regulating and supervising traffic, provide temporary roads and bridges for one-way traffic.
- (iv) Phase the execution of temporary and permanent works to minimize the disruption to traffic
- (v) Submit a phased program of temporary works one month before commencement of any part of the works.

5-2-3 Trench Crossings

Trench Crossings are to be provided for free and safe passage of vehicles and pedestrians over pipe trenches.

5-2-4 Temporary Site Fence

The Contractor shall provide a suitably secure temporary site fence where necessary or as directed by the Engineer. The design of the fence is to be submitted to the Engineer for approval.

5-2-5 Nameboard

The Contractor shall provide nameboards in both languages English and Arabic at suitable locations bearing the Employer's and Engineer's names, the name of the project, the Contractor's name and such other names and information as the Engineer may direct. Design of the name board shall be submitted for the Engineer approval prior to fabrication and erection.

5-3 Contractor's Temporary Offices

5-3-1 Contractor's Temporary Offices

The Contractor shall provide all necessary temporary sheds, offices, messrooms, sanitary accommodation and other temporary facilities required for his and subcontractors use.

5-3-2 Temporary Laboratory

The Contractor shall provide, furnish and equip a laboratory as necessary to carry out all testing of materials on Site required by the Specification, manned by suitably qualified staff.

5-4 Temporary Services

5-4-1 Water

The Contractor shall provide clean fresh water for the Works and make temporary arrangements for storing and distributing about the Site.

5-4-2 Electricity

The Contractor shall provide electric supply and all equipment for lighting and power for the Works and make temporary arrangements for distributing about the Site.

5-4-3 Power

The Contractor shall provide electric power for the Works including supplies for commissioning engineering services and plant, at the required voltages.

5-4-4 Lighting

The Contractor shall provide lighting for the Site and the Works for safety and security to the Works and to facilitate proper execution of work and to illuminate internal surfaces during finishing work and inspection. Spaces designed to be artificially lit during daylight hours are to have temporary illumination similar to that provided by the permanent installation.

5-4-5 Permanent Electric Supply And Lighting Installation

Permanent electric supply and lighting installation may be used for commissioning and to illuminate the Works subject to the following conditions:

- The employer does not guarantee that it will be available
- The Contractor must take responsibility for the operation maintenance and supervision of the system, indemnify the Employer against all damage and pay all costs and renew all used tubes and lamps
- The Contractor must indemnify the Employer against reduction in manufacturer's guarantee periods for equipment etc., due to its use before completion of the Works.

5-5 Temporary Facilities For The Engineer And/Or Employer

5-5-1 General

All facilities provided for the Engineer's and/or Employer's staff shall remain available until the end of construction period.

5-5-2 Representative's Site Offices

The Contractor shall provide 1 office per Caza rented to serve as offices as approved by the Engineer for the sole use of the Engineer's Representative and his staff, comprising:

- 3 offices size of each approximately 4m x 5m
- Meeting room for 12 people
- Secretary's room of approximately size 4m x 5m
- 1 kitchenette
- 2 toilets
- Car shades for 4 cars.

Offices are to be of proprietary manufacture, with hard-wearing, mosquito proof, weather proof, easy-clean surfaces and robust and secure fittings. The offices shall have full partitions and all rooms shall have individual entrance doors. Corridor and entrance areas shall be additional to the office size. All rooms shall have glazed windows complete with fly screens. The offices shall be provided with call bell system. The contractor shall submit full details to the Engineer's Representative for approval before delivery to the Site and erection.

5-5-2-1 Furniture And Equipment

Each office shall contain:

- 2 desks with lockable drawers and swivel chairs
- 2 lockable steel filing cabinets
- 2 office chairs
- 1 drawing hanger for 10 sets
- 2 shelves
- 2 pin boards
- 2 waste paper baskets.
- 1 reference table

And, in addition, the following shall be provided:

- 1 secretary's desk and swivel chair
- 2 large lockable sheet filing cabinets
- 2 reference tables
- 6 office chairs
- 10 calculators
- 1 photocopying machine with duplex, sorter and document feeder + consumables + all photocopying papers
- Pinboards, shelves and waste paper baskets.
- 1 computer minimum (or as may be required by the Engineer) with all consumables and all stationary and offices supplies.

5-5-2-2 Conference Room Furniture And Equipment

Details to be decided by the Engineer as needed and based on the following:

- 1 conference table for 12 people
- 12 chairs

- 2 pinboards
- 2 shelves
- 2 waste baskets
- 1 reference table.

5-5-2-3 Kitchen Furniture And Equipment

Shall comprise for each pantry:

- 1 refrigerator 14 cu. ft. capacity
- 1 water filter and 20 liters water cooler/hot/cold
- 2 electric boiling rings
- 1 stainless steel sink and drainer
- 1 heat resistant worktop
- 1 set of storage cupboards
- 1 set of crockery and cutlery for each member of the staff
- 1 large waste basket with cover.

And all necessary consumables for the making of beverages for the duration of the contract.

5-5-2-4 Store Room Furniture And Equipment

Shall comprise:

- Shelves units
- Drawing hangers and racks.

5-5-2-5 Lavatory Furniture And Equipment

Shall comprise for each lavatory:

- 1 european w.c. suite
- 1 toilet roll holder
- 1 wash hand basin with shelf
- 1 mirror
- 1 paper towel holder
- 1 soap dispenser
- 1 waste basket with cover.
- 1 extractor fan

And all necessary consumables.

5-5-2-6 Services

The Contractor shall provide and maintain the following minimum services:

- Heating and air-conditioning for each room office
- Electric lighting and power
- Water supply
- Drainage system

- Fire fighting appliances
- Cleaning facilities and general attendance.

All bills and charges related to the services shall be paid by the Contractor.

5-5-2-7 Telephones

The contractor shall provide a three separate telephone connections, one which is mobile and one fixed for office use and facsimile/internet, in addition to 3 mobiles. The Contractor shall pay all installation, rental and call charges.

5-5-2-8 Car Ports

Car ports, complete with hardstandings and all necessary adjoining walkways, shall be provided for a minimum of four vehicles. Covered car parking areas shall be adjacent to the offices.

5-5-3 Representative's Vehicles

The Contractor shall provide and maintain 2 new four wheel Drive per Caza, air-conditioned vehicles, minimum 2400 CC for the sole use of the Engineer's Representative and his staff and shall supply all fuel and lubricants, repair and maintain the vehicle to keep it in good roadworthy condition at all times, comprehensively insure the vehicle for any driver at all times and replace with identical vehicle any vehicle removed for maintenance or repair or for any other reason.

At the end of the Project the above car shall remain the property of the Contractor.

5-5-4 Vehicle Driver

The vehicle shall have a competent driver during normal working hours. The vehicle is to remain in the possession of the Engineer's Representative and his staff after normal working hours

5-5-5 Computer

The Contractor shall provide on site for the use of the Engineer's Representative and his staff two latest model computers and a laptop along with the necessary operating systems, softwares, A4 laser printer, A3 plotter and UPS.

5-5-6 Surveying Equipment And Assistance

The Contractor shall supply and maintain in full working order or shall replace whenever directed by the Engineer during the progress of the Work the surveying and other equipment scheduled below for the safe use of the Engineer's Representative and his staff and shall provide a topograph and other assistants if required.

5-5-7 Thermometers

The following shall be provided on Site:

- Maximum and minimum thermometer for measurement of atmospheric temperature
- Thermometer for measurement of concrete and ground temperature.

5-5-8 Test Equipment

The Contractor shall make available to the Engineer's Representative all test equipment and testing laboratories required for carrying out tests on materials, Plant or finished work required by the Specification.

5-5-9 Inspection Facilities

The Contractor shall provide all ladders, access lighting facilities and assistance etc. required by the Project Manager Representative/Engineer's Representative to inspect any part of the Works.

5-5-10 Digital Camera

The Contractor shall provide one digital camera latest model for the sole use of the Engineer's Representative and his staff.

5-6 Diversion Of Public Utility Services

5-6-1 Temporary Diversion Of Existing Public Utility Services

Where execution of the Works involves the temporary diversion of existing public utility services, the Contractor shall perform such temporary diversion and shall maintain the flow or service as directed by the Engineer. Unless otherwise stated the cost will be deemed to be included in the Contract Price.

5-6-2 Permanent Diversion Of Existing Public Utility Services

Where the works require the permanent diversion of existing public utility services, either where shown on the drawings or where directed by the Engineer, the diversion shall be carried out by the Contractor and shall be paid for at the prices stated for such work in the Bill of Quantities.

SECTION – II

SUB-SURFACE AND GEOTECHNICAL INVESTIGATIONS

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SECTION – II

SUB-SURFACE AND GEOTECHNICAL INVESTIGATIONS

200 – GENERAL

200.01 **Scope** - The geotechnical investigation works shall include, but not limited to, the following:

- Boreholes.
- Test pits.
- Field and laboratory tests.
- Presentation of results and comprehensive geotechnical report and recommendations.

The work shall be carried out with due and diligence and in accordance with internationally recognized professional codes and standards.

The Contractor's attention is drawn to the fact that the findings and recommendations presented by him will be used as a basis for subsequent design and construction works for highways, bridges and related structures and accordingly the Contractor shall be held responsible for the accuracy, completeness and validity of his work.

All work shall be carried out in accordance with approved work plans and time schedules and executed in accordance with the Contract Documents and the Engineer's directions.

The Contractor is required to observe and implement all measures necessary to ensure the safety, access, and convenience of the public. Such measures shall include, but not limited to, proper scheduling and phasing of the Geotechnical Investigation Works, effective provisions for uninterrupted access to properties; traffic diversions and traffic management; signage, barricades, warning lights and other measures, in and around work areas, for the protection of the public; and the suppression of pollution and noise.

The Contractor is required to coordinate fully with the Council for Development and Reconstruction (CDR), the Engineer, municipalities and other governmental authorities and other contractors executing work in the area. The location of the required boreholes and test pits is indicated in the specifications and drawings.

200.02 Codes and Standards

Except as otherwise specified or approved by the Engineer work shall be carried out in accordance with the following standards:

- American Society for Testing and Materials (ASTM)
- American Association of State Highway and Transportation Officials (AASHTO).
- British Standards Institution (BSI).

201 – GENERAL REQUIREMENTS FOR GEOTECHNICAL INVESTIGATIONS

201.01 Plant and Equipment - The Contractor shall arrange for and provide at his own expense all necessary equipment, plant, field and laboratory testing facilities and other instruments, tools and items required for the satisfactory execution and completion of the Geotechnical Investigation Works.

The Contractor shall submit a detailed list of equipment and other facilities which are proposed by him for use in carrying out the geotechnical investigations with names, qualifications and resumes of his geotechnical engineers, engineering geologists, and specialists to be assigned on these Works.

The Contractor's equipment, facilities and engineering staff proposed for carrying out the Geotechnical Investigations Works shall be subject to the Engineer's approval.

201.02 Maintenance and Spares

The Contractor shall provide adequate supply of spares and maintenance facilities for his equipment and other items used in the work in order to ensure good working order and progress of the work.

201.03 Program of the Geotechnical Investigations Works

The Contractor shall prepare and submit the work program for the Geotechnical Investigations within one week from date of the Engineer's Instructions or approval for carrying-out these geotechnical Works. The intended Work Programme shall be presented in such form and details as the Engineer shall reasonably prescribe, for the execution of the works.

The Contractor shall whenever required by the Engineer also provide a detailed description of the arrangements and methods which the Contractor proposes to adopt for the execution of the Works.

The Work program shall include full details of each operation, start and completion dates together with estimated manpower and equipment.

The Contractor shall revise and update the Work Program on periodic basis and whenever necessary as required by the Engineer.

201.04 Protection of Existing Utilities and Services

All works operations shall be conducted in a manner to avoid any damage to existing utilities and services and the Contractor is required to ascertain that the execution of boreholes and test pits does not interfere with or disrupt such utilities and services. Any damage caused by the Contractor's operations shall be made good by the Contractor and at his own expense. The locations at which boreholes and test pits have been performed shall be suitably backfilled and restored to their original condition.

201.05 Setting Out

The Contractor shall provide, establish and implement adequate procedures, staff and survey equipment as necessary for locating the position of the required boreholes and test pits.

Locations shall be established within a tolerance of 1.0 m of the designated positions; ground elevations established within 50 cm accuracy; and depths established within 50 cm accuracy.

201.06 Sequence of works

Boreholes and test pits shall be performed in the order approved by the Engineer. Boreholes Logs and test results shall be provided to the Engineer as the work proceeds and on daily basis.

201.07 Samples

All samples recovered from boreholes and test pits shall be placed in appropriate bags and containers and transported to the approved laboratory for testing. The Contractor shall not dispose of any such material, except as directed by the Engineer.

201.08 Measurement of Executed Works

Measurement of executed work shall be carried out progressively as the work proceeds and at intervals not exceeding one week. Such measurement shall be subject to the Engineer's approval.

201.09 Units of Measurements

All units of measurements shall be in accordance with the SI. Units.

201.10 Language

Unless otherwise approved by the Engineer, the Contractor's test results, reports, etc. shall be prepared in the English language.

202 – TECHNICAL REQUIREMENTS FOR GEOTECHNICAL INVESTIGATIONS

202.01 Field Investigation

Field investigation shall include the execution of boreholes and test pits at the designated locations, obtaining samples for visual and laboratory testing and determination of depths of subsurface soil strata, water table and other characteristics determinable during the execution of boreholes and test pits. Field Investigations shall be carried out in accordance with British Standards BS 5930: 1981 “Code of practice for Site Investigations.”

202.01.1 Test Pits

Test pits shall be excavated at approved locations & of 1.0 x 1.0 x 1.5 m depth. Bulk samples (50 kg) each of the soil material encountered shall be obtained from each test pit. Samples shall be placed in suitable bags and transported to the laboratory for subsequent testing.

Test pits shall be suitably backfilled and compacted and surfaces restored to their original condition.

Test pits location are tabulated in the specifications and shown on Drawings.

202.01.2 Boreholes

Boreholes shall be drilled using wet rotary or dry auger drilling equipment with a minimum diameter of 4 inches.

Boreholes locations and required depths are tabulated in the specifications and shown on Drawings.

Soil samples shall be obtained from the boreholes at 1.50 m intervals to termination depth. Undisturbed samples of cohesive soils shall be obtained using a 3-inch thin walled tube sampler (ASTM - D1587).

Disturbed samples of granular soils shall be obtained by driving a 2-inch split-barrel sampler with a 140 lb hammer falling 30 inch (ASTM - D1586). Penetration or driving resistance (Standard Penetration Test SPT) for the split-barrel sampler shall be recorded and presented as "blows per 15cm penetration" on the boring logs.

Where rock is encountered, continuous coring will be required. Diamond coring shall be performed in accordance with ASTM D2113. Description, recovery ratio and rock quality designation (RQD) shall be recorded on the boring logs. In such cases the use of double tube, swivel type core barrel may be adopted and the core diameter shall be not less than 2 inches (NWX, NWM). If rock is encountered at depth shallower than the designated borehole depth, the coring in rock shall terminate at a minimum depth of 3.0 m into bedrock. Coring shall not terminate in cavernous rock unless a minimum penetration of 3.0 m is achieved in sound bedrock.

Boreholes shall be left open for observation of ground water level and caving depth to be measured 24 hours after completion of boring. Such measurements and observations are to be recorded on the boring logs.

Geotechnical borehole logging, handling, labeling, and preservation of samples shall be undertaken in accordance with the British Standards BS 5930: 1981 "Code of practice for Site Investigations." The following shall also apply:

Samples obtained from boreholes shall be suitably handled, protected and transported to the laboratory for subsequent testing.

Materials obtained by coring shall be placed in wooden boxes divided by fixed separators into several rows indicating the sequence of drilling. Color photographs shall be taken for each of these boxes and included in the final Geotechnical Report.

202.02 - Laboratory Testing

The laboratory testing program for samples obtained from test pits and boreholes shall be primarily directed towards determination of the physical, chemical and engineering characteristics of the subsurface soils represented by the samples obtained in the field.

Laboratory tests shall be conducted in accordance with the Standard Testing Procedures stated below and shall be based on a detailed testing schedule and number of tests approved by the Engineer.

202.02.1	Testing Methods for cohesionless and cohesive soils	Test Standard
-	Moisture content of soils	D 2216
-	Particle size analysis of soils	D 422
-	Amount of material in soils finer than No. 200 sieve	D 1140
-	Dry unit weight	BS 1377: 1990
-	Specific gravity of soils	D 854
-	Liquid limit of soils	D 423
-	Plastic limit and plasticity index	D 424
-	Unconfined compression strength	D 2166
-	Unconsolidated undrained strength of cohesive soils in triaxial compression.	D 2850
-	Direct shear test	D 3080
-	One dimensional consolidation	D 2435
-	Sulphate content of soils	BS 1377: part3: 1990
-	Chloride content of soils	BS 1377: part3: 1990
202.02.2	Testing Methods for rocks	Test Standard
-	Dry unit weight	BS 1377: 1990
-	Unconfined compressive strength of intact rock core specimen	D 2938
-	Carbonate content	Chemical Method
202.02.3	Testing Methods for bulk samples from test pits	Test Standard
-	Particle size analysis of soils	D 422
-	Liquid limit of soils	D 854
-	Plastic limit and plasticity index	D 424
-	Moisture - Density relations of soils using 10-1b rammer and 18 in. drop, Method D. (Modified Proctor Test)	D 1557
-	Bearing ratio of laboratory compacted soils (CBR) (Soaked)	D 1883

202.03 Geotechnical Reports

The Contractor shall prepare and present to the Engineer fully comprehensive Geotechnical reports which shall include all data related to field investigations and laboratory tests together with analyses and recommendations where sections of the work are to be completed before the whole of the work, as designated in the Contract Document, a Geotechnical report shall be prepared and presented for each of such sections in accordance with the respective time or times for completion.

Geotechnical reports shall first be submitted in Final Draft Form for review and approval by the Engineer. Final Reports shall incorporate the Engineer's comments and any revisions or amendments required by the Engineer and finally submitted in Final Form and in five (5) copies within a maximum, period of five days after receipt of the Engineer's comments.

Geotechnical Report (s) shall include but without limitation the following:

- Summary
- Introduction
- Field Investigation
- Laboratory Investigation
- General Subsurface Condition
 - * Site conditions.
 - * General soil conditions.
 - * Groundwater levels.
- Analyses and Recommendations:
 - * Subgrade conditions.
 - * Compaction requirements for fill and exposed natural subgrade.
 - * Allowable soil bearing capacity and settlement estimates at the location of bridge foundations, retaining walls and structures.
 - * Embankments.
 - * Maximum height of vertical cuts and slopes for trenches.
 - * Earth pressure diagrams for retaining walls.
 - * Allowable pile capacities for bridge foundations.
 - * Slope stability analysis (if required).
- Construction recommendations:
 - * Pile installation (if required) (specify equipment).
 - * Excavations (specify equipment).
 - * Fill and compaction (specify equipment).
 - * Dewatering (if required).
- Illustrations:
 - * Plan of boring.
 - * Generalized soils profile.
 - * Logs of borings.
 - * Summary of Laboratory test results.
 - * Allowable pile capacities (if required).
 - * Slope stability results (if required).

203 – MEASUREMENT AND PAYMENT

203.01 Measurement of Sub-Surface and Geotechnical Investigations Items - Works included in the Sub-surface and Geotechnical Investigations such as drilling in soils, coring in rock, sampling and testing and others shall be measured in accordance with the units of measurements shown in the Bill of Quantities and stated below. Measured quantities shall be approved by the Engineer.

203.01.1 Field Test

- a. Measurement of Set-up on boreholes, Excavation test pits to 1.5m depth, and Obtaining bulk samples and description of soils in test pit shall be by the number of each type separately.
- b. Measurement of Drilling and sampling in any soil material, and Coring in rock and taking core samples shall be by the linear meter.

203.01.2 Laboratory Test - Measurement of all laboratory tests shall be by the number of each type separately.

203.01.3 Geotechnical Report - Geotechnical report shall be measured separately by item.

203.02 Payment for Sub-Surface and Geotechnical Investigations Works

Payment for Sub-surface and Geotechnical Investigations Works shall be at the rate inserted in the Bill of Quantities which rate shall, as appropriately applicable to each item of the Bill of Quantities, include for the complete cost of materials (including fuel), labour, equipment, transport, handling and preservation, overhead and profit and all other items required for the proper completion of the specific item of the sub-surface and geotechnical investigations in accordance with the Specifications and to the approval of the Engineer.

**** END OF SECTION ****

SECTION – III
DEMOLITION OF EXISTING STRUCTURES

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SECTION – III
DEMOLITION OF EXISTING STRUCTURES

300 – GENERAL

300.01 **Scope** - The work shall include but not be limited to:

- complete demolition and disposal of buildings and associated structures falling within the expropriation limits indicated on the Drawings,
- as above but partial demolition of buildings and associated structures and making good as specified,
- demolition and disposal of other structures within the road right-of-way.

The work shall be carried out as specified herein and as instructed by the Engineer.

300.02 **Submittals** - The Contractor shall prepare and submit to the Engineer for approval the following:

- 1- A fully detailed topographic and condition survey indicating the location, size, materials, level and other characteristics of all buildings and structures to be totally or partially demolished.
- 2- A method statement detailing the procedures, methods, sequence and schedule of demolition works.
- 3- Proposals regarding partial demolitions together with detailed procedures for protection, safety and structural work necessary to render the undemolished portions of buildings and associated structures in an acceptable condition.
- 4- A record of the location and other characteristics of existing utilities and services affected or likely to be affected by the demolition operations and the measures proposed to be taken by the Contractor for protection of same in coordination with the respective utilities owners and authorities.
- 5- The Contractor shall submit with his tender a detailed breakdown of each lump sum rate included under this section showing the number, quantity and type of structures to be demolished or partially demolished as appropriate together with the respective costs of the works to each structure.

No demolition work shall be commenced except after obtaining the Engineer's approval. Demolition work shall be carried out in accordance with approved submittals.

301 – DEMOLITION AND REMOVAL OF STRUCTURES

1. Unless otherwise indicated on the Drawings or directed by the Engineer, the Contractor shall demolish and remove all buildings and structures together with all foundations and retaining walls, piers, partitions and columns down to a plane not less than 1 meter below the ultimate grade in the area.
2. All structures shall be neatly trimmed off and the reinforcement shall be cut or burned off close to the concrete and made safe. Basement, floor slabs and the like shall be broken into pieces and all debris resulting from demolition work shall be removed and disposed of to approved dumping areas.
3. Upon receipt of approval of the Engineer, the Contractor shall take over all responsibility of the buildings and properties expropriated by the Employer and shall proceed with the demolition and removal thereof as specified.
4. The Contractor shall inspect each building and structure he is to demolish and remove and determine for himself the work involved and the equipment and the materials required.
5. The Contractor shall arrange for the discontinuance of any services to the structure or structures in accordance with the requirements and/or regulations of the Authority or owner concerned. The Contractor shall disconnect and properly seal in an approved manner any sewer outlets that serve any structure he is to remove. The Contractor shall keep the Engineer informed of his plans for the performance of any work in connection with the sealing off of such outlets in order that proper inspection can be provided at the time the work is performed.
6. The Contractor shall conduct his operations in such a manner as to avoid hazards to persons and vehicles. After work is started on any structure the work on that structure shall be continued to completion promptly and expeditiously.
7. Prior to the demolition of any structures, the Contractor shall be required to paint or stencil in contrasting colours warning signs on all four sides of each structure or building. Buildings intended to be partially demolished shall be properly identified to show the demarcation between the parts to be demolished and the parts to be retained. The Contractor shall verify the expropriation measures taken by the Employer and establish on the Site the limits of such expropriation.
8. Where buildings are to be partially demolished, the Contractor shall be responsible for shoring, support and structural stability of the parts of the building intended to be retained and shall carry out all structural work, erection of walls, masonry, plaster, tiling, painting and any other work required to render the remaining element of the building fit for use including restoration of water, wastewater, electric and telephone installations as appropriate. The exterior face where buildings have been partially demolished shall be restored by the Contractor to a satisfactory condition compatible with the other faces of the building.

9. All other structures and items required to be demolished including but not limited to walls, fences, walkways, pavements, curbs, tiles, culverts, pipes, manholes, inlets, surface water drainage channels, traffic road signs, posts for power and telephone utilities and the light, street lighting poles, street furniture and any other items, shall be demolished by the Contractor to a level of 1 meter below the ultimate grade in the area and removed and disposed of to approved dumping areas.

The Contractor is referred to the requirements of Clause 115 of Section I - General Requirements of the Specification with regard to the removal or re-location of any existing services and utilities.

10. The Contractor shall recover for storage or re-use any materials designated by the Engineer. Such materials shall be carefully handled by the Contractor and transported to storage areas of the concerned authorities as directed by the Engineer.
11. The Contractor shall cut back all existing construction in such a manner to avoid damage to the construction, which is to remain. The method of cutting back all existing construction shall be as approved by the Engineer.
12. Construction which is intended to interface or to connect or abut to partially demolished and new construction shall be carried out by the Contractor in a manner which is appropriate for the intended purpose and the Contractor shall furnish all materials, labour and workmanship required for interconnecting partially demolished and new work.
13. All necessary earthwork to uncover facilities to be demolished or removed and to backfill and compact all excavations resultant from demolition and removal shall be carried out by the Contractor in accordance with the specified requirements for earthwork.
14. The Contractor shall provide all necessary materials and equipment that may be necessary for dewatering and for temporary diversion and pumping of surface water and sewage required in connection with demolition work.

302 – MEASUREMENT AND PAYMENT

302.01 Demolition and Partial Demolition of Existing Structures, Buildings, Utilities Rooms, and Existing Bridge Structures

302.01.1 Measurement

- a. Demolition and partial demolition of existing buildings, utilities rooms, and tin roofed structures shall be measured by square meter irrespective of the floors heights and of floors numbers, for each type separately.
- b. Demolition and partial demolition of existing bridge structures shall be measured by number for each type separately.
- c. Demolition of existing shelter and concrete steps shall be measured by cubic meter.
- d. Demolition of existing shaft tunnel, existing sub-station and pump room, as shown on drawing shall be measured by lump sum item.

302.01.2 Payment - Payment shall be at the rate inserted in the Bill of Quantities, which rates shall be deemed to include the survey of all existing buildings, structures, utilities, shafts, etc. and bridge structures along the proposed route of the roads; the preparation and submission of the detailed method statement for the demolition or partial demolition of buildings, bridges, structures, and others, etc., all as detailed in this section of specification; all materials, labour, equipment necessary to execute such works; the removal of all surplus demolished materials to an approved dumping site to any hauling distance; temporary protection, shoring and all other safety measures; disconnecting and sealing of sewer outlets and all services to the buildings, bridges, structures, others, etc.; making good and restoration of exterior surfaces of buildings, bridges, structures and others, etc., partially demolished and the restoration of services to such buildings, bridges, structures, and others; all necessary excavations and backfilling, and breaking up into structures like concrete walls, cover slabs, and others, etc., and all other items and work necessary for the proper completion of demolition work.

302.02 Demolition and Partial Demolition of Existing Impeding Obstructions

302.02.1 Measurement - Demolition and partial demolition of existing impeding obstructions other than existing buildings and bridge structures shall be measured separately for each type as stated below:

- a. Demolition of existing pavements and existing paving structures shall be each measured separately by the square meter stating the type.
- b. Demolition and removal of existing kerbstones, concrete New Jersey barriers, edges, channels, pipes, and the like shall be by linear meter.
- c. Demolition and removal of existing barriers, fences with gates, and walls with doors and windows, including foundations shall be measured by linear meter for each type

separately. Measurements of walls shall be separated according to their following stage height ranges: up to 2.5m, over 2.5m but not exceeding 4m, other as stated in the Bill of Quantities.

d. Demolition and removal of existing vertical posts with foundations including traffic signs and lights, bollards and the like shall be by number for each type separately.

e. Demolition and removal of various concrete, reinforced concrete or masonry elements such as existing concrete walls, parapets, and the like, including foundations shall be by cubic meter.

f. Removal and relocation of existing trees shall be enumerated.

302.02.2 Payment - Payment shall be at the rates inserted in the Bill of Quantities, which rate shall be deemed to include for all labour, materials (including fuel), equipment, removal of demolished items, debris, etc. to an approved dumping site, overhead and profit, and all necessary protection works to carry out such works complete.

The Contractor's rates shall also be deemed to include for the removal for storage or re-use of all existing materials or other items so designated by the Engineer, unless such items are measured separately in the Bill of Quantities.

Removal of all buried utilities, to be abandoned and not to be relocated, shall be deemed to be included in Contractor's rates of earthworks.

**** END OF SECTION ****

SECTION – IV

EARTHWORKS

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SECTION – IV

EARTHWORKS

400 – GENERAL

400.01 **Scope** - This work shall consist of performing all operations necessary to complete clearing, grubbing, removing, whole or in part, within the designated limits or adjacent thereto and satisfactory disposal of debris, vegetation, abandoned pipe lines and any other obstructions which are not designated or permitted to remain; remove unsuitable materials; excavate selected material from the roadway and borrow pits for use as specified, the placing and compacting of selected material; structure excavation; backfilling; pervious backfill; and doing all the earthwork that may be required to construct and maintain the roadway facilities.

400.02 **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
BS 8006 Code of Practice for Strengthened/ Reinforced Soils and Other Fills

FHWA

US Department of Transportation, Federal Highway Administration (Geosynthetics Design and Construction Guidelines)

SETRA & LCPC

(SETRA: Le Service d' Etudes Techniques des Routes et Autoroutes)
(LCPC: Le Laboratoire Central des Ponts et Chaussées)

- "Ministère Des Transports, Direction Generale Des Transports Intérieurs, Les Ouvrages En Terre Armée - Recommendations et Règles de l' Art", par SETRA et LCPC.

- “Les Ouvrages de Soutènement - Guide de Conception Generale” par SETRA
- “Les Ouvrages en Terre Armée - Guide pour la Surveillance et le Renforcement” par SETRA

401 – MATERIALS UTILISED IN EARTHWORK CONSTRUCTION

401.01 Fill Material - The material used for filling and compacting low level areas of the roadbed, sidewalks, shoulder and drainage ditches and other areas on site shall consist of material approved for filling resulting from the excavation works carried out as specified in Clause 403.09 of these Specifications. In the event that such material is unsuitable or insufficient, the Contractor shall obtain and use approved filling material from borrow pits all in accordance with the provisions hereinafter detailed.

401.02 Water - The use of fresh water will be permitted for all Earthwork operations unless specifically stated to the contrary.

Potable water shall be used for compaction of backfill material within the area paid for as structural excavation or within an area of one metre from all surfaces of the structure, whichever is the lesser.

402 – MAIN MACHINERY UTILISED IN EARTHWORK CONSTRUCTION

402.01 General - The machinery and tools utilised in carrying out earthworks and other related works for the road construction shall be in good working condition and the Contractor shall maintain them in such condition for the whole duration of the works.

The Engineer shall approve the machinery and tools prior to the commencement of work and the Contractor shall supply an adequate number of tools and machinery as deemed necessary for the proper execution of the work with due speed and precision and shall by no means be limited to the types of equipment or recommended minimum number stipulated in the Contract Documents, which shall be used for guidance purposes only. The Contractor shall provide the Engineer with copies of catalogues, technical data, charts etc., of the machinery to be utilized on site prior to the commencement of the work.

Prior to commencing construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trials for each aspect of the earthworks to establish an approved rolling/compaction procedure which shall then be used as a minimum requirement for the permanent works unless otherwise directed or agreed by the Engineer.

The compaction trials shall involve all procedures specified for the permanent works including testing and any equipment, processes or procedures as proposed by the Contractor which are not included as a part of these specifications. Construction of the permanent works shall not commence until a rolling/compaction procedure has been approved in writing by the Engineer. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.

The compaction trials shall not be measured or paid for separately but shall be considered an incidental obligation of the Contractor under this Section of the Specifications.

402.02 Rotary Cultivators - They shall have axles rotated by a powerful motor and be equipped with metal teeth or plates. They shall be designed in such a way as to ensure proper pulverization and mixing of soil. They must be equipped with apparatus to lift and lower the axles so as to be always to the required depth.

402.03 Water Sprinklers - They shall be borne by trucks with pneumatic tyres and shall be equipped with a pressure pump and water sprinkling distribution equipment. The pump shall be powered in such a manner that the pump pressure will remain uniform regardless of variations in truck speed. The distributors shall be so designed as to allow sprinkling and adding of water to the soil uniformly and in controlled quantities and shall be equipped with an approved gauge to control the quantity of water added during operation. Special spray bar attachments shall be provided and used in order to sprinkle water on sloped sections.

402.04 Bulldozers - They may be tracked and/or pneumatic-tyred vehicles and shall be equipped with a blade for earth moving and levelling. Ripper attachment shall be provided when necessary. The blade level shall be hydraulically controlled to raise or lower it so that the work surface can be formed and adjusted as required.

402.05 Motor Graders - They should be pneumatic-tyred and shall be equipped such that it is possible to lift, lower and adjust the angle of the blade as required to control the grading operation and to perform grading without making any undulations.

402.06 Shovel Tractors - They shall be tractors equipped with a shovel for earth hauling or moving and may be either on tracks or on pneumatic tyres. The shovel must be hydraulically controlled to raise and lower it as required.

402.07 Rollers - Rolling equipment shall consist of pneumatic-tyred rollers and steel wheeled rollers as described below:

402.07.1 Pneumatic-Tyred Rollers - They shall be equipped with tyres of equal size and diameter which shall be uniformly inflated so that the air pressure of the tyres shall not vary by more than 0.35 kg/cm², one from another. The wheels shall be spaced so that one pass will accomplish one complete coverage equal to the rolling width of the machine. There shall be a minimum of 6 mm (1/4 inch) overlap of the tracking wheels.

Self-propelled pneumatic-tyred rollers shall comply with the following ratings:

- Minimum weight without ballast	9000 kg
- Minimum weight with ballast	18000 kg
- Minimum size of tyres	10 x 20 - 14 ply or 13 x 25 - 18 ply
- Tyre inflation pressure	3.9 - 8.4 kg/cm ²
- Minimum number of tyres	7
- Minimum wheel load	1300 kg
- Minimum wheel load with full ballast	2500 kg

402.07.2 Steel Wheeled Rollers - They shall be of four types, three-wheeled, tandem, vibratory steel tandem and single drum vibratory steel rollers.

- a. Three-Wheeled Rollers** - shall be self-propelled and equipped with a reversing clutch, a differential drive and with adjustable scrapers to keep the wheel surface clean. They shall comply with the following ratings:

- Manufacturer rating, kg,	15000
- Minimum diameter, rear wheel, metres	1.83
- Minimum width, rear wheel, metres	0.56
- Minimum compression per mm width of rear wheel, kg	8.32
- Minimum lap, each side, front and rear wheel, metres	0.86
- Maximum rolling speed, km/h	3.2

- b. Tandem Rollers** - shall be self-propelled equipped with reversing clutches, sprinkling system having a storage tank of not less than 320 litres (70 gallons) to spray front and rear rolls and adjustable spring scrapers fitted to the driving and steering roll to scrape in both directions. They shall comply with the following ratings:

- Manufacturer rating, kg (unballasted)	7000 - 8000
- Manufacturer rating, kg (ballasted)	10000 - 12000
- Minimum diameter, driving roll, metres	1.32
- Minimum diameter steering roll, metres	1.02
- Minimum rolling width, metres	1.27
- Minimum compression, per mm width of driving roll, kg	3.49
- Maximum driving speed, km/h	3.20
- Minimum wheel base, metres	3.05

- c. Vibratory Steel Tandem Rollers** - Vibratory steel tandem rollers shall have the requirements of the foregoing steel tandem rollers with a static weight of at least 5000 kg and a vibrating frequency between 1500 and 2000 cycles per minute.

- d. Single Drum Vibratory Steel Rollers** - They shall be double axle, self-propelled Units with the rear axle equipped with pneumatic flotation wheels. They shall have vibrating frequency capabilities between 1500 and 2000 cycles per minute.

402.07.3 Portable Vibratory Compaction Rollers - They shall be double axle tandem single-drum self-propelled equipped with a vibrating element delivering an impact of not less than 1590 kg at a frequency of about 5000 cycles per minute. The roller shall be easily maneuverable, of an adequate width and suitable for rolling ditches and side slopes.

402.07.4 Mechanical Hand Compactors - Hand compactors shall be capable of delivering an impact of between 750 to 1500 kilograms.

403 – METHOD OF EXECUTION OF WORKS

403.01 Bench marks and Monuments

403.01.1 General - Before commencing the works the Contractor shall obtain from the Engineer all information pertaining to project related bench marks and monuments bearing the National grid coordinates. The Contractor shall be responsible for maintenance of these bench marks and monuments throughout the Contract period. He shall also establish supplementary bench marks and monuments as may be necessary or as directed by the Engineer. All pertinent levels, lines and locations must be checked and verified by the Contractor before commencing the works.

403.02 Setting Out - The Contractor shall be responsible for the true and proper setting out of the work in relation to original points, lines and levels of references given in the Drawings and for the accuracy of the positions, levels, dimensions and alignment of all parts of the work and for any delay or loss resulting from errors made in completing the setting out of the works. The Contractor shall protect, preserve and be responsible for all existing bench marks, pegs and boundary marks and shall keep them in place or replace them when necessary either in their positions or in some other approved positions.

403.03 Survey of Existing Ground Levels - The Contractor will survey cross-sections of the Site prior to the commencement of work in any section.

The Contractor shall include in his Critical Path Programme the date by which survey work should be completed in each section of the site. No work may commence in any section prior to the programme date without the written approval of the Engineer.

Sections will be prepared at such intervals as are necessary to give a representative record of existing conditions and in no case will the intervals exceed 50 metres.

The Contractor will give the Engineer 48 hours notice of his intention to carry out survey work in any particular section of the site and the Engineer may nominate a representative to be present to observe the survey.

The Contractor will prepare drawings showing the various cross-sections obtained from the above survey. The original of the drawings shall be signed by the Engineer and the Contractor as an agreed record of the existing ground levels. These drawings shall be used as the basis for remeasurement of the works as specified.

403.04 Clearing and Grubbing - The Contractor shall excavate and/or remove and cart away surface material such as debris, vegetation and any other unsuitable material in the areas and to the thickness instructed by the Engineer. Clearing and grubbing shall be restricted to removal of unsuitable surface material and debris and shall not include the excavation of natural ground or the removal of existing pavements unless directed by the Engineer. The material shall be loaded and carted away to an approved dumping area. The Contractor shall be responsible for obtaining the location of the dumping area as well as the necessary permits and approvals from the relevant authorities. The volume of such surface material shall be incorporated in the calculations unless specifically mentioned otherwise.

All surface objects and trees, stumps, roots and other protruding obstructions, shall be cleared and/or grubbed as required except as provided below:

- a. In areas outside of the grading limits of cut and embankment areas, stumps and non-perishable solid objects shall be cut off not less than 500 mm below finished ground level.
- b. In areas to be rounded at the top of cut slopes, stumps shall be cut off flush with or below the surface of the final slope line.
- c. Grubbing of pits, channels changes and ditches will be required only to the depth necessitated by the proposed excavation within such areas.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted in accordance with these specifications.

All materials removed shall be disposed of by the Contractor in a lawful manner.

403.05 Excavation and Removal of Unsuitable Soil - Where excavation to finished grades and cross sections exposes unsuitable soil or other unsuitable material in the subgrade, slopes or ditch inverts, etc the Engineer may require the Contractor to excavate and remove the unsuitable material and backfill the excavated area with other suitable surplus material or approved imported material in layers not exceeding 200mm compacted thickness and to the density specified. The Contractor shall conduct his operations in such a way that necessary cross sections measurements are taken before backfill is placed. Garbage, waste and debris are included in the unsuitable soil materials to be removed with no extra cost.

The Engineer may designate as unsuitable, soils that cannot be properly compacted in embankments. Unsuitable material shall be carted away to approved dumping areas or shall be deposited elsewhere on site as directed and approved by the Engineer. Wasted unsuitable material shall not be deposited on any cropland.

When the Contractor is directed to excavate unsuitable material below the surface of the original ground in fill areas, other than that required for cleaning and grubbing, the depth to unsuitable material shall be removed will be determined by the Engineer. The Contractor shall schedule excavation so that cross-sections are taken before and after material has been removed.

The Contractor may be permitted to lay geotextile membrane over unsuitable material in lieu of excavation and removal of such material and backfilling, all subject to the prior written approval of the Engineer. Geotextile membrane shall comply with the requirements of Clause 409.01 of these Specifications.

403.06 General Excavation - The Contractor shall excavate in all materials including rock for the full width of the road construction (within limits of Contract inclusive) down to the top of the required sub-grade. He shall then scarify a layer not less than 300 mm deep except that this requirement shall not apply where rock is present. The soil shall be pulverised, watered as required, mixed, shaped and compacted to 95% density in accordance

with these specifications to a depth of 300 mm. Should the material that would have formed this 300 mm deep scarified and re-compacted layer not comply with the requirements specified for sub-grade material, the material shall be removed and replaced with suitable material to the extent directed by the Engineer. The replacement material shall be compacted to 95% density and after completing the compaction of a layer, the Contractor shall lightly disc or score the surface of the layer to ensure a good bond with the subsequent layer.

Suitable and approved excavated material from any part of the site shall be hauled and used for filling in any other section of the Site in accordance with these specifications. The Contractor shall at his own responsibility and expense store such material when necessary, until the need arises for its use in filling as required by the phases of construction, or as directed by the Engineer.

Where the amount of suitable material excavated exceeds the amount of fill required for the Works, the Contractor shall dispose of the surplus material at approved dumping areas.

403.07 Rock Excavation - 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 0.5m³ 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. Any artificially formed solid matter such as blockwork or concrete shall not be considered as rock.

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. Such logging shall be incorporated in the measurement of percentages and quantities of rock out of excavated soil as extra over other soil excavations.

The Contractor, at his own responsibility and expense, shall supply any equipment and labour necessary to obtain samples and for testing. The Engineer shall determine the location and quantity of samples necessary to determine the extent of the rock. These samples shall be taken in the presence of the Engineer.

In the event that the tests prove that the material is rock, the Engineer shall determine the extent of such material and shall instruct the Contractor accordingly.

403.07.1 Rock Blasting - 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 suspending of 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.

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 of as directed.

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.

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.

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.

403.08 Manual Excavation - The Contractor shall excavate manually in the vicinity of all services, structures and any other areas and if necessary uncover them, all as directed by the Engineer. Excavations shall be carried out taking all precautions to prevent damages to services, properties and persons and any damage resulting from the negligence of the Contractor, his agents, or his employees, shall be repaired at the Contractor's expense. The Contractor shall have no right to claim any expenses or delays resulting from his failure to abide by the Engineer's directions. No separate payment shall be made for manual excavation which shall be included in the rate for excavation works.

403.09 Suitable Fill Materials Resulting from Excavations - The material used for filling and compacting low level areas of the roadbed, sidewalks, shoulder and drainage ditches and other areas on site shall consist of material approved for filling resulting from the excavation works carried out as specified hereinafter. In the event that such material is unsuitable or insufficient, the Contractor shall obtain and use approved filling material from borrow pits all in accordance with these specifications. The Contractor, prior to using material resulting from excavation for filling, shall carry out necessary field and laboratory testings at his own responsibility and expense to establish the suitability of said material for filling work and whenever such excavated material indicates change in characteristics, the Contractor shall carry out additional testing and shall secure the Engineer's approval for its use. No mixing of different types of soils or soils imported from different sources is allowed.

Fill material shall be clean and free from any unsuitable material.

Unsuitable material shall include material from marshes, stumps and perishable material, organic material and chemically contaminated material, material of liquid limit exceeding 40 as determined by AASHTO T89 and/or plasticity index exceeding 12 as determined by AASHTO T90 and any other material that does not meet the specification requirements for fill material.

403.09.1 Suitable Fill Materials Resulting from Earth Excavations - The Suitable material resulting from earth excavations which shall be used for filling and compacting embankments, low level areas of the roadbed, sidewalks, shoulder and drainage ditches, and other areas and locations shown on the drawings, shall be placed in loose lifts not exceeding 250mm thickness and shall have the following gradation:

<u>Sieve Size (mm)</u>	<u>% Passing</u>
100	100
75	75 - 100
0.075	0 - 15

Material passing No. 40 sieve shall have a liquid limit not exceeding 40 and a Plasticity Index not exceeding 12.

403.09.2 Fill Materials Resulting from Rock Excavations - Where excavated material resulting from rock excavations shall be used for backfilling and compacting areas and locations shown on the drawings, the Contractor shall break all oversize rock materials which are otherwise suitable for construction, according to these specifications, down to a maximum required sizes of 25 cm rocks accepted to be incorporated in filling materials.

Embankments constructed using fill materials resulting from rock excavations, as specified above, shall be constructed in successive layers for the full width of the individual embankment cross section. The thickness of each layer shall be limited to a maximum of 500mm and the maximum rock size shall not exceed 250mm. Each layer shall be levelled and smoothed with suitable levelling equipment and by distribution of spalls and finer fragments of earth. Lifts of material containing more than 25% of rock larger than 150 mm in greatest dimension shall not be constructed above an elevation 300 mm below the top of finished subgrade.

Each layer shall be constructed by starting at one end and dumping the rock on top of the layer being constructed, then pushing the material ahead with an approved “Bulldozer” in such manner that the larger rock will be placed on the ground or preceding embankment layer and the interstices between the larger stones will be filled with small stones and spalls by this operation and from the placing of succeeding loads of material.

403.10 Filling Low Level Areas/Embankment or Widening Existing Embankments - Filling low level areas shall be up to the level of subgrade as shown on the drawings.

After completion of clearing and grubbing as required, the Contractor shall carry out the necessary levelling in order to control the thickness of the layers of fill.

The existing natural ground shall then be scarified in place to a minimum depth of 200 mm for the full width of the embankment except where the material is classified as rock. The scarified material shall be watered as required, thoroughly mixed, shaped and compacted to a minimum of 95% density in accordance with these Specifications. If the material in the scarified layer fails to meet the specified requirements, the material shall be removed and replaced with suitable material to the extent directed by the Engineer and compacted to a minimum of 95% density in accordance with these Specifications. Subsequent layers of fill material shall then be placed and compacted in accordance with the specified requirements.

Where an existing embankment is being widened, the existing embankment slope shall be trimmed and compacted to form a step prior to placing and compacting each layer of new embankment material unless otherwise directed by the Engineer to suit particular circumstances.

The Contractor shall not proceed with filling and compacting any subsequent layer prior to securing the approval of the Engineer for the previous layer.

After securing the approval of the Engineer, the Contractor shall lightly disc or score the surface of the approved layer to ensure a good bond with the subsequent layer.

All material below the subgrade level must meet the requirements of the Specification for the depths indicated on the drawings.

No separate payment shall be made for filling low areas/embankments or widening existing embankments which shall be included in the rates for other items in the Bill of Quantities as noted in these Specifications.

There shall be no separate payment for scarifying, processing and compacting the existing natural ground.

403.11 Filling around and/or on Culverts, Stormwater Pipes, Utilities and Structures - Filling in these areas shall be done in accordance with the applicable sections of these Specifications.

Filling for these areas shall be from surplus excavated material obtained from site and approved by the Engineer. In the case of insufficiency of such material then approved material shall be obtained from borrow pits and filled to the levels as indicated on the Drawings. The maximum size of particle allowed in the backfill within one metre of culverts, stormwater pipes, utilities and structures shall be 50 mm.

403.12 Borrow Pits (Additional Fill) for Roadworks - If the surplus suitable material obtained from excavation is less than the quantities required for filling, the Contractor shall supply filling material from borrow pits, provided such borrow pits and borrow fill material are approved by the Engineer.

It is the Contractor's responsibility to satisfy himself that there is sufficient borrow material of suitable types to meet the Specification requirements. The Contractor may elect to use alternative sources of borrow material.

It shall be the Contractor's responsibility to obtain all permits or permission and make any payments that may be required in acquiring the rights to borrow material.

The Contractor shall allow in his rates for all costs arising from excavating borrow material. Any delays or losses incurred will be the sole responsibility of the Contractor.

The Contractor shall obtain and supply to the Engineer representative samples from the borrow pits he intends to use. The Engineer will be afforded the opportunity to be present during the sampling operations. The Contractor shall carry out the necessary laboratory (and, if required, field) testing to establish the suitability of the material for filling work.

The Contractor shall test samples of the approved borrow pits material actually being imported onto the site and should such material fail to meet the requirements of these Specifications, approval to the use of the borrow pits will be withdrawn and the Contractor shall immediately cease importation from the borrow pits until such time as the Engineer may approve alternative sources of material from within the same borrow pits based on sampling and testing as specified above.

The Engineer will decide whether the material already imported from the concerned borrow pits can remain as placed on the site, or whether the Contractor shall remove and replace the said material at his own expense.

403.13 Compaction - The Contractor shall carry out the required compaction specified after grading and levelling the surface to be compacted. In areas to be filled, compaction shall include adding necessary soil, water etc. and compacting the first layer in addition to subsequent layers up to the proposed levels. In areas already excavated down to the required level, compaction shall include adding the necessary water, etc. and compacting the surface, in accordance with the procedure outlined herein after.

No separate payment shall be made for compaction which shall be included in the rates for excavation and/or filling works.

The procedure outlined below shall not relieve the Contractor of his duties to determine the most suitable procedure all subject to the approval of the Engineer.

- a. After carrying out the grading, levelling, scarifying, pulverising etc., of the soil layer to be compacted as per Specifications, the Contractor shall add the necessary amount of water to permeate the pulverised soil in the quantity required.
- b. The soil shall then be thoroughly turned over after each addition of water so as to achieve a homogeneous moisture content in the whole thickness of the layer.
- c. Before compacting, samples of the pulverized soil shall be tested using a 'Speedy Moisture Device' or similar instrument to establish the moisture content. If the moisture content is not within $\pm 2\%$ of the optimum Moisture Content as determined by AASHTO T180, the area represented by this sample shall be scarified and aerated or water added until the moisture content is within $\pm 2\%$ of the optimum Moisture Content. The soil shall then be primarily levelled in order to commence earth compaction.

- d. After primary levelling referred to above, compaction shall be commenced by means of approved rollers depending on the type of soil being compacted in order to obtain the required density.

Filling shall be in layers not exceeding 250 mm loose thickness.

All roadways, medians, shoulders, sidewalks, verges and the like shall be compacted to 95% as determined by AASHTO T180. Fill material that is mainly cohesionless with less than 10% fines should be compacted to a relative density not less than 60% as determined by ASTM D4253 and ASTM D4254.

- e. The rolling shall be carried out in the direction of the road axis until the soil reaches the required density. In crowned sections, rolling shall start from both edges of the road in the direction of the axis. If the road is super-elevated, rolling shall commence from the lower side and continue to the higher side. In order to compensate for the amount of water loss in evaporation during the course of compaction, additional quantities of water shall be added as required.
- f. The final surface shall thereafter be levelled longitudinally and transversely by motor graders and finally rolled to achieve uniform compaction free from undulations, soft spots and depressions all in conformity with the allowable tolerances for evenness of surfaces.
- g. Compacting of sloped sections of the road embankments and drainage ditches shall be carried out as herebefore specified with regard to pulverisation of soil, addition of the necessary water, shaping, compaction to the required degree of compaction and the required design sections.
- h. Prior to placing material for any subsequent layer the surface shall be lightly disced or scored.

403.14 Filling Between Median Barriers - The Contractor shall take every precaution to protect the bridge columns, lighting equipment etc., when filling between median barriers and any damage to these items arising from the filling works shall be made good at the Contractor's expense.

Unless otherwise shown on the drawings the fill material between median barriers shall be compacted to 90% density in accordance with the Specifications. The Contractor shall agree the type of plant or equipment to be used with the Engineer prior to undertaking this work.

403.15 Borings - The Contractor shall perform all work required to auger or core boreholes or test borings in locations directed by the Engineer.

The Contractor shall not carry out such borings unless the Engineer or his representative is present.

The work shall be carried out in accordance with Section II - Sub-Surface and Geotechnical Investigations.

403.16 Subgrade Preparation - This work shall consist of the preparation of the graded roadbed upon which the pavement structure layers are to be placed, all in accordance with these Specifications.

403.16.1 General - All subgrade shall be compacted to the requirements of Clause 403.13 and Clause 404.01 of these Specifications.

Once prepared, the subgrade shall be maintained in the finished condition until the first succeeding layer of the pavement structure has been placed. The Contractor shall take all precautions necessary to protect the subgrade from damage; hauling over finished subgrade shall be limited to that which is essential for construction purposes. Any equipment used for hauling over the prepared subgrade which in the opinion of the Engineer is causing undue damage to the prepared subgrade or to the underlying materials shall be removed from the work at the request of the Engineer. All cuts, ruts and breaks in the surface of the subgrade shall be repaired prior to placing any subsequent layer at the Contractor's expense. The Contractor shall protect the prepared subgrade from both his own and public traffic. The Contractor shall maintain the subgrade by blading and rolling as frequently as may be necessary to preserve the subgrade in a completely satisfactory condition.

403.16.2 Subgrade Preparation Requirements in Filling Sections - Material selected for use in the top 300 mm of fill areas in addition to meeting the requirements of Clause 401.01 shall be of A1 or A2 AASHTO classification and shall have a minimum California Bearing Ratio (CBR) equal to or greater than 10, when compacted to 95% of AASHTO test method T-180. Materials in the A1 AASHTO classification will not require consideration of CBR value.

403.16.3 Subgrade Preparation Requirements in Cut Sections – The top 300mm of the subgrade material in cut sections shall meet the requirements of Clause 401.01 and shall have a minimum California Ratio (CBR) equal to or greater than 10, when pulverized and recompacted to 95% of AASHTO test method T-180 and to these Specifications.

Materials not conforming to these Specifications shall be either excavated, and replaced with Sub-base material and compacted to the required density or covered with geotextile membrane as directed and approved by the Engineer.

404 – TESTING

404.01 Inspection and Control of Material and Work - For verification of material, moisture content, compaction, thickness etc., the Engineer shall at all times have access to all portions of the Works and Sites. All sampling and testing of material and work shall be carried out under the direction of the Engineer.

404.01.1 Testing of Materials - Materials shall be tested by AASHTO, ASTM, or other approval equal test or procedure designated in the Specifications.

Test	AASHTO Designation
Sampling	T2, T86
Sample Preparation	T87
Sieve Analysis	T27, T11, T88
Liquid Limit	T89
Plastic limit & Plasticity Index	T90
Moisture Content	T93, T217

Test	AASHTO Designation
Moisture-Density Relationship	T180
Sand Equivalent	T176
Specific Gravity	T100
California Bearing Ratio (C.B.R.)	T193 (Modified for T180 compaction)
Classification of Soil and Soil Aggregate	
Mixtures for Highway Construction Purposes	M145

Test	ASTM Designation
Maximum Index Density	D4253
Minimum Index Density	D4254

404.01.2 Testing Degree of Compaction - Testing shall be done in accordance with an AASHTO method of testing, ASTM or other approved equal test or procedure designated in the Specifications.

Test	AASHTO Designation
Sampling	T86
Density in-Place (Sand Cone Method)	T191
Density in-Place (Drive Cylinder Method)	T204
Density in-Place (Rubber Balloon Method)	T205
	ASTM Designation
Density in-Place (Nuclear Method)	D5195

The density of any layer requiring compaction shall be determined in accordance with the AASHTO specifications at a minimum rate of one test per 100 metre run or 1000 metre square, whichever is less; however if the first time pass rate exceeds 80% the frequency may be reduced to one test per 2000 metre square. If a layer does not conform with the required density, additional tests may be taken to determine the limits of the failing area, after which the Contractor shall rework the area until the specified density is obtained. The Contractor shall allow enough time in his daily work programme to permit the performance and checking of the above tests, before he proceeds into any subsequent operations.

404.02 Testing Levels and Evenness of Subgrade Surface - The levels and evenness of the finished subgrade surface, shall be tested to ascertain their conformity to the Drawings and Specifications.

The Contractor shall make available to the Engineer a four metre straight edge and a crown template of sturdy and approved design and the necessary labour to assist in any checking operations.

Requirements:

- a. When tested by a four-metre straightedge placed at right angles to, or parallel to, the road centerline or when tested by a crown template placed centrally at right angles to the road centreline, the maximum gap between the road subgrade surface and the testing edge shall not be greater than 20 mm.
- b. Variation in the falls to cross-sections of the road shall not exceed 0.4%, nor shall the levels of the finished surface vary by more than + 10 mm or - 20 mm from the required levels.
- c. These tests shall be made at any point requested by the Engineer. In the event of any failure, correction of the surface shall be carried out at the Contractor's expense to the satisfaction of the Engineer.

405 – MEASUREMENT AND PAYMENT

405.01 Excavation and Removal of Unsuitable Soil

405.01.1 Measurement of Excavation and Removal of Unsuitable Soil – Excavation and removal of unsuitable soil shall be measured by the metre cube, in place, as executed. Data relevant to such excavation and removal shall be agreed between the Engineer and Contractor at the time of excavation of the unsuitable material and shall be incorporated into the drawings prepared for site levels.

405.01.2 Payment for Excavation and Removal of Unsuitable Soil – Payment shall be at the rate included in the Bill of Quantities and the rate shall include for excavating, loading, carting away and dumping of excavated material as specified. Payment for the backfilling of excavated areas of unsuitable materials shall be included under payment for General Excavation as stated hereinafter in these Specifications.

405.02 General Excavation - Measurement and payment for general excavation shall apply only to those areas occurring above top of subgrade level and/or finished ground level.

405.02.1 Measurement of General Excavation - The method of measurement of general excavation shall be by the metre cube calculated from the difference between existing ground levels after clearing and grubbing and final subgrade levels and/or finished ground levels as per the Drawings and as specified herein. This calculation shall include the volume of rock excavation, but exclude the volume of existing pavement, kerbs, foundations and the like (measured separately under Demolition of Existing Structures) as determined by the Engineer.

Where the full width of the subgrade is contained on both sides and below within a structure (e.g. trough or tunnel) then the measurement of excavation for such work shall be included in Structure Excavation.

405.02.2 Payment for General Excavation - Payment shall be made at the rate included in the Bill of Quantities, which rate shall include for General Excavation (excluding

Structural Excavation), haulage and stockpiling of excavated material for backfilling, including spreading, leveling & compacting of the suitable material in layers or the disposal of unsuitable or surplus suitable material. The rate shall also include for the backfilling of excavated areas of unsuitable materials, all in accordance with these Specifications and so instructed by the Engineer.

Rate for Structural Excavation shall be as defined under Structural Excavation.

The above rate shall also include shaping and compacting the roadbed, shoulder, drainage ditches, sidewalk and side slopes including the adjustment of slopes in cut and fill sections and performing all required setting out, cross-sectioning testing and the like all in accordance with the Specifications and in conformity with the Drawings.

405.03 Rock Excavation *(As part of the General Excavation)-*

405.03.1 Measurement of Rock Excavation – There will be no separate payment for rock excavation. The volume of such rock shall be accounted for in calculating volumes of general excavation defined in these specifications.

405.03.2 Payment for Rock Excavation - Payment for such rock excavation included as part of the measurement of general excavation volume shall not be made separately, but shall be made at the same rate of general excavation of any soil material defined in sub-clause 405.02.2, inserted by the Contractor in the priced Bills of quantities.

405.04 Borrow Pits (Additional Fill) for Roadworks

405.04.1 Measurement of Borrow Pits (Additional Fill) for Roadworks - The method of measurement for this work shall be made by calculating the difference between the total volume of fill required including filling behind and between barriers and the volume (as calculated in place in its original location) of all suitable filling material arising from the works.

405.04.2 Payment for Borrow Pits (Additional Fill) for Roadworks - Payment shall be made at the rate included in the Bill of Quantities which rate shall include for but not by way of limitation, excavating, loading, hauling, off loading, spreading, levelling, watering and compacting and for all requirements including the payment for any charges made in respect of materials obtained from borrow pits. The rate shall also include shaping and compacting the roadbed, shoulder, drainage ditches, sidewalks and slopes and performing all required testing, all in accordance with the Specifications and in conformity with the drawings.

No extra payment shall be made for additional fill to compensate for shrinkage or settlements and the Contractor is deemed to have allowed for this in his rates.

Payment under this clause shall also include for any necessary stock-piling and double handling of filling material and all measures to ensure that as-excavated suitable material remains in a suitable condition for incorporation in the works. Any as-excavated suitable material which, in the opinion of the Engineer, is unsuitable for incorporation in the works at the required time, shall be removed from the site and shall be replaced by suitable material from borrow pits at the Contractor's expense.

405.05 Clearing and Grubbing

405.05.1 Measurement of Clearing and Grubbing – Measurement shall be by meter square. The area of this work shall be that area to be cleared and grubbed contained within the Right of Way limits (R.O.W) excluding the area of existing roads, sidewalks and the like. No account shall be made to the Contractor for clearing and grubbing outside these limits unless such work is authorised by the Engineer in advance.

405.05.2 Payment for Clearing and Grubbing – Payment shall be at the rate indicated in the Bill of Quantities which rate shall include full compensation for all labour, materials and equipment.

405.06 Shaping and compacting side slopes

405.06.1 Measurement of Shaping and compacting side slopes - Measurement shall be by square meter of the finished subgrade of side slopes with a slope equal to or steeper than 1 in 2.

405.06.2 Payment for Shaping and compacting side slopes - Payment shall be made at the rate indicated in the Bill of Quantities.

405.07 Subgrade Preparation

405.07.1 Measurement of Subgrade Preparation - Subgrade preparation shall be measured by the meter square. Subgrade preparation will not be measured where the subgrade is formed by a concrete structure.

405.07.2 Payment for Subgrade Preparation - Payment shall be at the rates included in the Bill of Quantities, which rates shall be full compensation for providing all labour, materials and equipment for performing subgrade preparation, including subsequent protection of subgrade, as specified herein and as directed by the Engineer.

Subgrade preparation will not be paid for where the subgrade is formed by a concrete structure.

405.08 Dewatering and Protection and Strutting the Sides of any Excavation

405.08.1 Measurement - No separate measurement shall be made for dewatering, keeping all areas free from water, protection and strutting the sides of any excavation.

405.08.2 Payment - No separate payment shall be made for dewatering, keeping all areas free from water, protection and strutting the sides of any excavation, which shall be deemed to be included in other rates and prices of the Bill of Quantities.

406 – EMBANKMENT CONSTRUCTION

406.01 Materials – Materials approved for filling and compacting embankments shall be to the requirements of Clause 403.09 of these Specifications.

406.02 Stepping of Existing Ground for Embankments – Where indicated on the drawings or directed by the Engineer, the surface of hillsides to receive embankments shall be loosened by scarifying or plowing to a depth of not less than 100mm, and cut into steps before embankment materials are placed. The embankment shall then be placed in layers as required in these specifications.

406.03 Design Criteria for all types of Earth Retaining Structures – The following design parameters shall apply to the design of all types of Earth Retaining structures:

- a. Design Life: Minimum 100 years.
- b. Earthquake ground acceleration: 0.2g
- c. Surcharge loading: 20 Kpa
- d. Reinforced Soil Materials:
 - Angle of internal Friction (ϕ): 33° to 36°
 - Unit Weight: 19 KN/m³
 - Cohesion: 0 Kpa
- e. Factors of Safety:
 - Bearing Capacity: greater than or equal to 3.0
 - Sliding: greater than or equal to 1.5
 - Deep seated (overall) stability: greater than or equal to 1.5
 - Dynamic (earthquake): greater than or equal to 1.1
- f. Design Analysis and Codes:

Analysis and design Calculations with all relevant documents, drawings, details, and supporting sheets shall be submitted by the Contractor to the Engineer for approval. Analysis and design shall be prepared in compliance with applicable and internationally approved design codes. Unless otherwise approved by the Engineer, the applicable codes for the design of Geogrid and Earth Fill Retaining Structures “Terre Armee” shall be the latest version of the following codes and standards:

- BS 8006: Code of Practice for Strengthened/Reinforced Soils and Other Fills
- US Department of Transportation, Federal Highway Administration (Geosynthetic Design and Construction Guidelines)

- “Ministere des Transports, Direction Generale Des Transports Interieurs, Les Ouvrages En Terre Armee- Recommendations et Regles de l’art, par LCPC et SETRA”.
- “Les ouvrages de Soutenement - Guide de Conception Generale” par SETRA.
- “Les ouvrages en Terre Armee - Guide pour la surveillance et le renforcement” par SETRA.

g. Design Analysis Softwares:

Software/Softwares used in the Design Analysis shall be submitted to the Engineer for approval before proceeding with the analysis. Certificates and Proof of legal purchasing from an internationally recognized Institution including full clarification of Input, Output and Design parameters and symbols shall also be submitted for the Engineer.

406.04 Mechanically stabilized earth walls (Geogrid type) – The Geogrid materials shall be used for the construction of earth retaining walls, embankments, and slope protection.

406.04.1 Requirements - Geogrid design, construction and materials shall comply with the following requirements:

Geogrid shall be manufactured in accordance with the Quality Assurance requirements of ISO 9002-1987 (EN 29002/BS 5750, Part 2, 1987). Related Certification of conformance of the materials to above standard shall be made available to the Engineer.

Geogrid shall be manufactured from High Density Polyethylene sheet, oriented in one direction so that the resulting ribs shall have a high degree of molecular orientation which is continued through the integral traverse bar.

Real Time creep tests on the geogrid, or earlier versions using the same polymer and manufacturing method, shall have been carried out for a period of not less than 10% of the design life. If creep testing has been carried out for shorter periods then the strength should be factored in accordance with Annex A.3.3.3 of BS 8006.

The geogrid shall have an appropriate partial factor for site installation and construction damage, determined by the particle size distribution of the reinforced fill and in accordance with the values used in the design. This factor shall be based on full scale tests carried out in accordance with BS 8006 Annex D. If required by the Engineer, the contractor shall provide supporting documented evidence of testing for this and any other partial factors assumed in the design. The strength of the junctions between the longitudinal ribs and transverse bars, as determined by the Geosynthetics Research Institute, Drexel University, USA, test method GG2-87, shall not be less than 100% of the Quality Control Strength.

Any site joints in the reinforcement roll length shall be capable of carrying more than 90% of the geogrid Quality Control Strength when tested in accordance with ISO 10321. If required by the Engineer, the contractor shall carry out testing to demonstrate this.

The geogrid shall be inert to all chemicals naturally found in soils and shall have no solvents at ambient temperature. It shall not be susceptible to hydrolysis, and shall be resistant to aqueous solutions of salts, acids, alkalis, and shall be non bio-degradable.

Geogrid shall have a minimum of 2% of divided black carbon to inhibit Ultraviolet light attack.

Reinforced fill materials to be used with this system shall be Suitable fill materials as defined in Clause 403.09.1 of these Specifications.

406.05 Mechanically stabilized earth walls (Earth Fill Retaining System “Terre Armée”) – The system is composed of major elements:

- Earth fill
- Reinforcement
- Concrete facing

The three elements have to meet special criteria in order to be accepted for use in this system. The Contractor is to propose his design calculations for the proposed system using actual selected fill material obtained from the site excavations.

406.05.1 Reinforced Earth Fill – Reinforced earth fill materials used with this system shall be Suitable backfill materials as defined in Clause 403.09.1 of these Specifications and shall also have the following criteria:

- Angle of internal friction of saturated material shall exceed 25° if the reinforcement used is high tensile steel, and 22° if the reinforcement used is mild steel.

Method for test shall be as per the French Recommendations of the French Ministry of Transport.

- Water content shall not exceed the optimum water content for compaction.
- The Resistivity of the fill material shall exceed 1000 Ohm-centimeter for fill above water, and 3000 Ohm-Centimeter for fill in non-salty water.
- The P.H. of the material shall be between 5 and 10.
- Soluble salt content: in particular chlorides and sulfates shall not exceed:

$$\begin{array}{lcl} [\text{Cl}^-] & < 200 \text{ mg / kg} & \} \\ [\text{SO}_4^{2-}] & < 100 \text{ mg / kg} & \} \text{ for fill above water} \end{array}$$

$$\begin{array}{lcl} [\text{Cl}^-] & < 100 \text{ mg / kg} & \} \\ [\text{SO}_4^{2-}] & < 500 \text{ mg / kg} & \} \text{ for fill in non-salty water} \end{array}$$

- Organic material: No organic material shall be accepted in the fill.

406.05.2 Reinforcement – Mild steel, galvanized or not, is the most commonly used. However, high tensile steel is also used. The reinforcement shall be in conformity with the required characteristics defined by SETRA in “Les Ouvrages en terre armée – Recommendations et Règles de l’Art”.

406.05.3 Reinforced Concrete Facing – Reinforced concrete facing shall be precast and vibrated. The concrete shall be of $f'c = 300\text{kg/cm}^2$, and the reinforcement shall be as defined by the manufacturer, and supported by calculations.

406.06 Measurement and Payment for Mechanically Stabilized Earth Walls (MSE Walls):

406.06.1 Measurement of MSE walls:

MSE walls shall be measured by square meter stating the height range of wall, with each range varying within a height interval of 1 meter elevation. The height of MSE walls stated in the Bill of Quantities shall be measured vertically from top of foundations beam to top of MSE wall or top of reinforced concrete wall constructed above where adopted.

406.06.2 Payment of MSE walls:

Payment for MSE walls shall be at the rate included in the Bill of Quantities which shall include full compensation for the design (including drawings, calculation sheets, catalogues leaflets, data sheets, certification including testing certificates, warranties, and other related works and required documents to be submitted for the review and approval of the Engineer). The rate shall also include for the extra height of MSE walls due to the slope of the face of wall and benching. The rate shall also include the cost of earthworks including excavation and backfilling with the suitable and appropriate type of soil (selected aggregate based fill). Rate shall also include for furnishing all materials required for the proper execution of this type of MSE walls (including fabricating furnishing and installation of walls facing, reinforcement and tie strips, fasteners, joint fillers and incidentals), full compensation for the construction of the wall foundations, placing and installation of the reinforcing strips, and erecting the panel or facing elements to the lines and grade shown on shop drawings approved by the Engineer.

407 – STRUCTURAL EXCAVATION AND BACKFILL

407.01 General - In addition to the work specified, the Contractor shall include all operations necessary to excavate and backfill all as required for the construction of the structures as shown on the Drawings, as specified herein and as may be required for all construction and directed by the Engineer.

This work shall consist of the necessary excavating, in all materials including rock, for bridges and other structures and utilities not otherwise provided for in the Specifications. Unless otherwise provided, the backfilling of completed structures and the disposal of all excavated material shall be in accordance with the Specifications and in reasonably close conformity with the Drawings or as established by the Engineer.

This work shall include necessary bailing, pumping, dewatering, draining, sheeting, bracing and the necessary construction of cribs and cofferdams and furnishing the materials therefor and the subsequent removal of cribs and cofferdams and the placing of all necessary backfill.

The Contractor shall take all necessary precautions, to the satisfaction of the Engineer, to prevent loss of natural cementation in the existing subsoil during and as a consequence of, dewatering operations.

This work shall also include the furnishing and placing of approved foundation fill material or plain concrete to replace unsuitable material encountered below the foundation elevation of structures.

Laid back excavation slopes shall not be permitted without the written permission of the Engineer. Where such permission is not granted or where only a part of the overall depth of an excavation is permitted to be laid back, all vertical faces of excavation greater than one and one half metres in height shall be supported unless otherwise agreed in writing by the Engineer. Such agreement shall not relieve the Contractor of his responsibilities under the Contract.

Prior to commencing any structural excavation work greater than one and one half metres in depth, the Contractor shall submit to the Engineer for his approval details of the proposals for laying back excavations and/or supporting vertical excavated faces.

The proposals shall be submitted in the form of calculations and drawings which clearly indicate the extent of excavation at all points along the structure relative to adjacent properties, roads and services.

In the case of vertical excavations the proposals shall comprise detailed drawings of the support system stating method of installation and showing support member materials, sizes, spacing and engineering calculations to validate the design of the above, including the maximum theoretical deflections of the support members. The support system shall be designed in such a manner that no raker struts or any other support members extend through surfaces exposed in the finished construction and no shoring or bracing is placed under permanent structures.

The Engineering calculations shall show lateral earth pressures for the full excavation depths, forces at various stages of support during installation and removal and concrete placement, the anticipated equipment loads, surcharge loads of any description, the maximum design loads to be carried by various members of the support system and strut preload forces.

If the structure support system proposed includes tie-back anchors, the Contractor's submittal drawings shall show the profile of the soil in which each anchor is to be installed, the design load for the full depth of the excavation, the maximum design and proof loads, surcharge loads of any descriptions, equipment loads, forces at various stages, support during installation and removal and the criteria proposed for deformations under proof loads.

Where a proposed system of tie-back anchors projects beyond the vertical projection of the Contract limit lines shown on the Drawings on to the adjoining property, the permission of

the owner shall be obtained in writing and such permission submitted to the Engineer at the time the shop drawings of the support system are submitted.

All expenses for the design and construction of structure excavation support systems shall be considered incidental to the structure excavation and shall not be measured or paid for separately.

At locations where the excavation extends below the ground water table, a de-watering system shall be provided which will effectively reduce the hydrostatic pressure and lower the groundwater levels below excavation levels, as required for the safe and proper excavation of the work and which will result in obtaining a stable, dry subgrade for the execution of subsequent operations.

The Contractor shall design de-watering methods and settling basins so that no critical amounts of soil, sand or silt are removed during either the initial operations or the construction operations. Complete working drawings showing the type of de-watering and ground water control system proposed shall be submitted to the Engineer for his review.

The Contractor's submittal drawings shall show the arrangement, location and depths of the proposed de-watering system if required. A complete description of the equipment and materials to be used and the procedure to be followed shall be shown, together with the standby equipment, standby power supply and the proposed location or locations of points of discharge of water.

Any required de-watering system design shall also include the measures taken to prevent damage due to settlement of pavement, utilities, buildings and other structures outside the excavation but within the area affected by the de-watering procedures.

Dewatering, including system design, equipment, pumping and disposal of water shall not be measured or paid for separately but shall be considered incidental to the excavation work.

Dewatering shall not be terminated without the approval of the Engineer and in the case of structures retained by ground anchors dewatering shall not be terminated until the ground anchors have been stressed to the full working load and approved by the Engineer.

The designs of the structure excavation support systems and the dewatering systems specified above shall be prepared by and signed by a professional engineer specialising in this type of design work. The professional engineer shall be approved by the Engineer.

407.02 Excavation - General, All Structures - The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-sectional elevations and measurements may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without the permission of the Engineer.

Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the Drawings, or as ordered by the Engineer. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The elevations of the bottoms of footings, as shown on the Drawings shall be considered as approximate only and the Engineer may order, in writing, such changes in

dimensions or elevations of footings as may be deemed necessary, to secure a satisfactory foundation.

Boulders, logs and any other objectionable material encountered in excavation shall be removed.

Unless otherwise provided for in the Contract Documents or directed by the Engineer structure excavation shall be carried out for a width of at least 500 mm beyond the horizontal outside limits of the foundation, footing, box culvert or structural member to which the excavation relates. Concrete blinding or subfoundations are not to be considered as structure for the purpose of defining such excavation.

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 or cyclopean 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.

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.

After each excavation is completed, the Contractor shall notify the Engineer to that effect and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the material on which the foundations will bear.

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.

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 or cyclopean concrete for high load carrying structures including bridge foundations and retaining walls. The foundation fill shall be placed and compacted in 250 mm layers up to the foundation elevation. Compaction shall comply with these specifications.

407.03 Utilisation of Excavated Materials - All excavated material, so far as it is suitable, shall be utilised as backfill or roadway fill. No excavated material shall be deposited at any time so as to endanger the partly finished structure.

All excavated material shall be approved by the Engineer before being utilised as fill. All surplus excavated material and excavated material rejected by the Engineer for use on the site shall be removed from the site and disposed of to approved dumping areas.

The Contractor shall include all handling, off-loading, spreading, levelling, watering and other related work as directed by the Engineer.

407.04 Cofferdams - Suitable and practically watertight cofferdams shall be used wherever water-bearing strata are encountered above the elevation of the bottom of the excavation. Upon request, the Contractor shall submit Drawings showing his proposed methods of cofferdam construction.

Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as directed by the Engineer. The foundation shall then be dewatered and the footing placed.

If weighted cribs are employed and the weight is utilised to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorages such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level as directed.

No separate payment shall be made for cofferdams which shall be included in the rate for structure excavation.

As an alternative to a cofferdam, the Contractor may propose a well-point dewatering system, for approval by the Engineer, to keep structural excavation works dry. Such proposal shall include but not be limited to sufficient calculations, sketches, drawings, etc. to justify the well-point positions and lengths in addition to pumping capacity required. The use of a well-point dewatering system may not preclude the use of support or shoring within the excavation to provide adequate stability and safety to the satisfaction of the Engineer and which shall be provided at no extra cost.

No separate payment shall be made for well-point dewatering which shall be included in the rate for structure excavation.

407.05 Backfill - Excavated areas around structures shall be backfilled with selected excavated materials approved by the Engineer or approved borrow fill material. Backfill materials shall be placed in horizontal layers not over 250mm (loose) 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.

Where indicated on the Drawings, backfill material behind bridge abutments and retaining walls shall be suitable material as determined in Clause 403.09 of these Specifications.

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

Embankment and backfill behind walls of any culvert shall not be placed until the top slab of the culvert has been placed and cured. Backfill to culvert sidewalls shall be carried up simultaneously behind opposite sidewalls.

407.06 Measurement and Payment

407.06.1 Measurement and Payment for Structural Excavation

407.06.1.1 Measurement of Structural Excavation - Measurement shall be by the metre cube. The volume of structure excavation to be paid for shall be the product of the cross-sectional area of the excavation and the length of each such section.

The cross-sectional area shall be determined as indicated and as described below:

- Limits for Horizontal Dimensions

In sections to be backfilled - vertical planes 500 mm outside and parallel to the neat line of the footings (excluding blinding concrete).

- Limits for Vertical Dimensions

The underside of blinding concrete beneath the structure and original ground level or finished ground level or subgrade level (following general excavation) whichever is the lowest, at each point across the section.

Where the subgrade is contained on both sides and below for its full width within a structure (e.g. trough or tunnel sections) the limits for vertical dimensions, for the section between the back faces of the retaining walls/abutments forming the trough or tunnel, shall be from underside of the blinding for the structure to the lower of the following:

- a. original ground level, or
- b. an imaginary line from the back face of the retaining walls/abutments on each side of the trough or tunnel section joining the finished ground level or subgrade level, whichever is the lower on each side.

Excavation above subgrade level and finished ground level shall be included in general excavation.

407.06.1.2 Payment for Structural Excavation - Payment shall be at the rate in the Bill of Quantities which rate shall include for, but not be limited to, materials, equipment, labour, workmanship and other related costs, overhead costs and profit for structure at excavation,

dewatering, pumping, excavation support systems, pregrouting, ground stabilization, and all things necessary to complete the works in accordance with these Specifications, the Drawings and the instructions of the Engineer. Payment for Structural Backfill shall be as stated hereinafter.

Further, the unit rate for structural excavation shall include for loading, hauling, off-loading and other related work as directed by the Engineer.

Where no separate item for excavation is indicated in the Bill of Quantities or, if excavation is stated as being included, no separate measurement or payment shall be made for such work which shall be deemed to be included in the rates and prices of the Bill of Quantities.

407.06.2 Measurement and Payment for Rock Excavation

407.06.2.1 Measurement of Rock Excavation - No separate measurement shall be made for excavation in rock.

407.06.2.2 Payment for Rock Excavation - No separate payment shall be made for excavation in rock, which shall be deemed to be included in the rate of structural excavation.

407.06.3 Measurement and Payment for Structural Backfill

407.06.3.1 Measurement of Structural Backfill - Measurement shall be by the metre cube. The volume of structural Backfill shall be equal to the volume of structural excavation as measured in the relevant section of these specifications reduced by the volume of structures poured within the excavation limits.

407.06.3.2 Payment for Structural Backfill - Payment shall be at the rate in the Bill of Quantities which rate shall include for, but not be limited to, materials, equipment, labour, workmanship and other related costs, overhead costs and profit for structural backfilling with suitable approved excavated materials and all things necessary to complete the works in accordance with these Specifications, the Drawings and the instructions of the Engineer. Further, the unit rate for structural Backfilling shall include for loading, hauling, off-loading, spreading, leveling, watering and other related work as directed by the Engineer. shall include for testing materials prior to use in backfilling, including all required field, laboratory and quality control tests for soil material with oversize particles meeting the requirements of these specifications; such tests include the required field compaction trial test sections.

Where no separate item for backfilling is indicated in the Bill of Quantities or, if backfilling is stated as being included, no separate measurement or payment shall be made for such work which shall be deemed to be included in the rates and prices of the Bill of Quantities.

No extra payment shall be made for additional fill to compensate for shrinkage or settlements and the Contractor is deemed to have allowed for this in his rates.

407.06.4 Measurement and Payment for Backfilling with Imported Borrow Fill

407.06.4.1 Measurement of Backfilling with Imported Borrow Fill - Measurement of backfilling structures (other than culverts, manholes, chambers and the like) with imported borrow fill material shall be measured in cubic meters.

407.06.4.2 Payment for Backfilling with Imported Borrow Fill - Payment shall be at the rate inserted in the Bill of Quantities which rate shall be deemed to include for the additional costs in respect of excavating, loading, hauling, off loading, spreading, leveling, watering and compacting and for all requirements including the payment for all charges in respect of materials obtained from borrow pits and performing all required testing, all in accordance with the Specifications and in conformity with the drawings.

No extra payment shall be made for additional fill to compensate for shrinkage or settlements and the Contractor is deemed to have allowed for this in his rates.

407.06.5 Measurement and payment for structural excavation and backfilling including breaking up and demolishing existing structures-

407.06.5.1 Measurement for structural excavation and backfilling including breaking up and demolishing existing structures-

Measurement for structural excavation and backfilling including breaking up and demolishing existing structures shall be in lump sum item as shown on drawings.

407.06.5.2 Payment for structural excavation and backfilling including breaking up and demolishing existing structures-

Payment for structural excavation and backfilling including breaking up and demolishing existing structures shall be made at the rate included in the Bill of Quantities which shall include but without limitation, excavation works, backfilling works, demolition, upholding excavation sides and shoring, dewatering, allowance for the cost of materials, labour, equipment and all other items required to complete the works.

407.06.6 Measurement and payment of excavation for placed riprap (loose riprap)

407.06.6.1 Measurement of excavation for placed riprap (loose riprap)

Measurement of excavation for placed riprap (loose riprap) shall be in Cubic meters.

407.06.6.2 Payment of excavation for placed riprap (loose riprap)

Payment of excavation for placed riprap (loose riprap) shall be made at the rate included in the Bill of Quantities which shall include but without limitation, excavation works around the abutments or piers of the viaducts, allowance for the cost of materials, labour, equipment and all other items required to complete the works.

408 – PREFABRICATED SHEET DRAIN

408.01 Scope – Works shall consist of furnishing and installing prefabricated sheet drainage system as a hydrostatic water relief system and tie into water discharge system, or weep holes as and where shown on the Drawings including, jointing, drainage structures and backfilling.

408.02 General – Prefabricated sheet drain shall be used in vertical applications such as retaining walls and bridge abutments.

408.03 Quality Assurance Testing – Sheet drain must be backed by letter of certification from manufacturer that the flow rate in the plane of core meets or exceeds the specified flow given under typical properties per ASTM D 4716.

408.04 Material – Prefabricated sheet drain must be a composite system consisting of permeable geotextile and three dimensional polymeric core providing equal flow in two perpendicular directions.

Material shall be delivered in original packages bearing the manufacturer's name. The fabric shall not be exposed to direct sunlight for more than two weeks during its storage and installation.

Firmly attach the geotextile to the core so folding, wrinkling, or other movement cannot occur either during handling or after placement. Achieve bonding using nonwater-soluble adhesive, heat sealing, or other method recommended by the manufacturer. Do not use adhesive on areas of the permeable geotextile fabric where flow is intended to occur.

Required Physical Properties

Fabric

Material	Polypropylene	
Grab tensile strength	Not less 485 N	ASTM D4632
Puncture strength	285 N	ASTM D4833
Trapezoidal tear	Not less than 200N	ASTM D4533
Mullen burst strength	1400 kPa (minimum)	ASTM D3786
Elongation at break	Not less than 60%	ASTM D4632
AOS	150 micron	ASTM D4751
Permeability	Not less than 0.39 cm/sec	ASTM D4491
Flow rate	6110 lpm/m ²	ASTM D4491

Core

Material	Polystyrene	
Thickness	Not less than 6.0 mm	
Flow capacity per unit	Not less than 110 lpm/m	ASTM D4716
Compressive strength	Not less than 275kPa	ASTM D1621

408.05 Construction Requirements – The prefabricated sheet drain system should be installed by methods approved by the manufacturer.

408.06 Measurement and Payment

408.06.1 Measurement – Prefabricated sheet drain shall be measured by square meter of covered area, furnished, installed, backfilled, completed and accepted. Permeable geotextile, required attachments, accessories and related works are all considered as part of the system.

408.06.2 Payment – Payment shall be at the rate inserted in the Bill of Quantities which shall include full compensation for furnishing all materials, including hauling, processing and for furnishing all labour, equipment, tools and incidentals to complete the work.

409 – GEOTEXTILE MEMBRANE

409.01 General - Geotextile membrane shall be non-woven polyethylene or polypropylene fabric having the following minimum properties:

- 1) Grab tensile strength 650 N to ASTM 1682,
- 2) Puncture resistance (CBR) maximum load 1250 N to B.S 6906,
- 3) Burst strength 1300 KN/m² to ASTM D 3786 and
- 4) Trapezoidal tear strength 350 N to ASTM D 1117.

409.02 Measurement and Payment for Geotextile Membrane

409.02.1 Measurement - Geotextile Membrane shall be measured by square meters of covered area. The overlap shall not be measured.

409.02.2 Payment - Payment shall be at the rate included in the Bill of Quantities which shall include full compensation for furnishing the geotextile materials, laying and installation, including for furnishing all labour, equipment, tools and incidentals to complete the work. The overlap shall not be measured and shall be considered included in the unit rate included in the Bill of Quantities.

410 – SLOPE PROTECTION AND STABILIZATION

410.01 Scope - These Works shall consist of the furnishing of materials and construction of riprap slope protection and riprap headwalls; reinforced concrete slope protection, gabion slope protection and grid and mat slope protection.

410.02 Materials

410.02.1 Geotextile Under Riprap- Geotextile shall be of the long-chain type made of synthetic polymers, composed at least 95 percent by mass of polyolefins or polyesters which are required in order to manufacture geotextile or the threads used to sew geotextile. The geotextile shall be formed, including selvages, into a stable network such that the filaments or yarns retain their dimensional stability relative to each other.

(a) Physical requirements. Conform to the following table for the type of geotextile specified:

Type IV (A - F) Permanent erosion control type of geotextile shall be used. The physical requirements of the required geotextile shall be in accordance with Table 410.1.

All property values, with the exception of apparent opening size (AOS), in these specifications represent minimum average roll values in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the specified values). Values for AOS represent maximum average roll values.

Geotextile shall be elevated and protected in rolls with a waterproof cover, if stored outdoors. When using a geotextile for a permanent installation, the geotextile exposure to ultraviolet radiation shall be limited to less than 10 days.

(b) Evaluation procedures. A commercial certification, including the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile, is required.

When samples are required, remove a 1-meter long, full-width sample from beyond the first outer wrap of the roll. Label the sample with the lot and batch number, date of sampling, project number, item number, manufacturer, and product name.

In addition, when geotextile joints are sewn, submit the seam assembly description and a sample of the sewn material. This description shall include the seam type, seam allowance, stitch type, sewing thread tex ticket number(s) and type(s), stitch density, and stitch gauge.

If the production seams are sewn in both the machine and cross-machine directions, provide sample sewn seams that are oriented in both the machine and cross-machine directions. Furnish a sewn sample that has at least 2 meters of sewn seam and is at least 1.5 meters wide. Sew the sample seams with the same equipment and procedures that are used to sew the production seams. For seams sewn on-site, conform to the manufacturer's recommendations. Obtain approval of the seam before installation.

Table 410.1
Physical Requirements for Permanent Erosion Control Geotextile

Property	Test Method ASTM	Units	Specifications ⁽¹⁾					
			Type IV-A	Type IV-B	Type IV-C	Type IV-D	Type IV-E	Type IV-F
Grab strength	D 4632	N	1400/900	1400/900	1400/900	1100/700	1100/700	1100/700
Sewn seam strength	D 4632	N	1260/810	1260/810	1260/810	990/630	990/630	990/630
Tear strength	D 4533	N	500/350	500/350	500/350	400 ⁽³⁾ /250	400 ⁽³⁾ /250	400 ⁽³⁾ /250
Puncture strength	D 4833	N	500/350	500/350	500/350	400/250	400/250	400/250
Burst strength	D 3786	kPa	3500/1750	3500/1750	3500/1750	2750/1350	2750/1350	2750/1350
Permittivity	D 4491	s ⁻¹	0.7	0.2	0.1	0.7	0.2	0.1
Apparent opening size	D 4751	mm	0.43 ⁽²⁾	0.25 ⁽²⁾	0.22 ⁽²⁾	0.43 ⁽²⁾	0.25 ⁽²⁾	0.22 ⁽²⁾
Ultraviolet stability	D 4355	%	50 % after 500 hours of exposure					

(1) The first values in a column apply to geotextiles that break at <50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at

(2) Maximum average roll value.

(3) The minimum average roll tear strength for woven monofilament geotextile is 245 N.

410.02.2 Riprap Rock. Furnish hard, durable, angular rock that is resistant to weathering and water action and free of organic or other unsuitable material. Do not use shale, rock with shale seams, or other fissile or fissured rock that may break into smaller pieces in the process of handling and placing. Riprap Rock shall be Class 5 in conformance with Table 410.2 and shall also comply with the following Criteria:

- (a) Apparent specific gravity, AASHTO T 85 2.50 min.

- (b) Absorption, AASHTO T 85 4.2% max.
- (c) Coarse durability index, AASHTO T 210 50 min.
- (d) Gradation for the class specified Class 5 as specified in table Table 410.2

Table 410.2
Gradation Requirements for Riprap

Class	Percent of Rock by Mass	Mass (kg)	Approximate Cubic Dimension⁽²⁾⁽³⁾ (mm)
1	20	10 to 15	150 to 200
	30	5 to 10	125 to 150
	40	0.5 to 5	50 to 125
	10 ⁽¹⁾	0 to 0.5	0 to 50
2	20	25 to 50	200 to 250
	30	10 to 25	150 to 200
	40	1 to 10	75 to 150
	10 ⁽¹⁾	0 to 1	0 to 75
3	20	100 to 150	350 to 400
	30	50 to 100	250 to 350
	40	5 to 50	125 to 250
	10 ⁽¹⁾	0 to 5	0 to 125
4	20	250 to 350	450 to 500
	30	100 to 250	350 to 450
	40	10 to 100	150 to 350
	10 ⁽¹⁾	0 to 10	0 to 150
5	20	700 to 1000	650 to 700
	30	350 to 700	500 to 650
	40	25 to 350	200 to 500
	10 ⁽¹⁾	0 to 25	0 to 200
6	20	850 to 1600	700 to 850
	30	500 to 850	550 to 700
	40	50 to 500	250 to 550
	10 ⁽¹⁾	0 to 50	0 to 250

- (1) Furnish spalls and rock fragments graded to provide a stable dense mass.
- (2) The volume of a rock with these cubic dimensions has a mass approximately equal to the specified rock mass.
- (3) Furnish rock with breadth and thickness at least one-third its length.

410.02.3 Mortar (Cement Grout) - Mortar for grouted riprap shall consist of 1:3 cement / sand mortar by volume. Water added shall be the least amount which will yield a mix of suitable consistency to ensure proper mortaring of riprap.

410.02.4 Wire Mesh for Slope Protection - Wire mesh (netting) for slope protection, shall consist of galvanized steel chain-link fabric conforming to ASTM A392: "Zinc Coated Steel Chain-Link Fence Fabric". The minimum wire diameter shall be 4.8mm (No.6 AWG). Wire for splicing wire mesh sheets shall have a diameter matching that of the wire mesh and shall consist of galvanized steel structural wire conforming to ASTM A603: "Zinc Coated Steel Structural Wire Rope".

410.02.5 Wire Fabric for Riprap Enclosure - Wire fabric shall conform with the requirements of ASTM A116: "Galvanized Steel Woven Wire Fence Fabric" Class 2, minimum 4mm diameter (No.8 AWG). Tie wires shall conform to ASTM A641: "Galvanized Carbon Steel Wire", Class 3, soft or medium temperature minimum 4mm diameter.

410.02.6 Geogrid Fabric – Geogrid, mat and soil nails for slope protection to be used were required. The material shall be in compliance with the requirements listed in section 406.04.

410.02.7 Gabions – Gabions shall consist of approved type galvanized steel wire mesh baskets (or other approved types such as heavy duty plastic mesh) filled with selected riprap before installation.

Galvanized steel wire mesh shall conform to ASTM A390 Class 3, or equivalent and with the requirements shown on the Drawings. The wire mesh shall be twisted to form hexagonal or rectangular openings of uniform size. The maximum nominal opening size shall be 100mm. Mesh shall be constructed so as to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut.

Baskets shall be furnished in one or more sizes, which can be assembled to provide the minimum dimensions, stability and structural integrity of the installation specified. Sizes of gabion baskets will normally be 2m long by 1m wide by 0.5m to 1m high. Non-standard sizes shall be provided to suit the particular installation. Baskets shall be fabricated in such a manner that the sides, ends, lid and diaphragms between adjacent baskets, for use as foundation mattresses, etc., may not require lids. Base, lid, ends and sides shall be either moved into a single unit or one edge of these members connected to the base section of the gabion in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

All perimeter edges of the mesh forming the basket shall be securely clip bound or selvaged so that the joints formed by tying have at least the same strength as the body of the mesh.

Perimeter (edge), tie and connection wires shall conform to ASTM A 641, Class 3, Medium Temper and the minimum diameters shown on the Drawings.

Riprap material for filling of gabion baskets shall consist of rocks conforming to Riprap Class A size, clean, strong, durable and highly resistant to weathering. Dimensions shall range from 250mm to approximately 125mm diameters. Not more than 5% shall be smaller than 100mm.

410.03 Construction

410.03.1 Preparation of Slopes – The surfaces upon which riprap and other slope protection Works are to be placed shall be excavated and compacted to the required grades and lines and a footing trench where specified, shall be excavated along the toe of the slopes, all as shown on the Drawings or as directed. All footing trenches and prepared areas shall be approved prior to placement of riprap or concrete. Subgrade or base shall firm or compacted as directed.

410.03.2 Loose Riprap – Placed Riprap (Loose Riprap). Placed riprap is rock placed on a prepared surface to form a well-graded mass.

Place riprap to its full thickness in one operation to avoid displacing the underlying material. Do not place riprap material by methods that cause segregation or damage to the prepared surface. Place or rearrange individual rocks by mechanical or hand methods to obtain a dense uniform blanket with a reasonably smooth surface; as shown on the drawings or directed by the Engineer.

410.03.3 Grouted Riprap. Grouted riprap is rock placed or keyed on a prepared surface with the voids filled with grout.

Place rock for grouted riprap and thoroughly moisten the rocks and wash excess fines from the riprap or to the underside of the riprap. Place grout only when the air temperature is no less than 1 °C within the near-surface voids of the riprap. Place the grout in a manner to prevent segregation. Begin placing grout at the lowest elevation of the riprap. Fill all voids without unseating the rocks. Thickness of grouted riprap shall be of 300mm. Allow 3 days curing time before adding the next layer of riprap and grout. Provide weep holes through the grouted riprap as required. Keep the grouted riprap moist for 3 days after the work is completed and protect it from freezing for a minimum of 7 days after grouting.

410.03.4 Wire Mesh Slope Protection – Wire mesh slope protection shall be installed in accordance with the typical details and at the locations, as shown on the Drawings.

410.03.5 Wire Fabric Enclosed Riprap – Riprap enclosed with wire fabric shall be constructed in accordance with the typical details and at the locations, as shown on the Drawings. Riprap shall be placed and finished as specified for loose stone riprap.

410.03.6 Geogrid Fabric – Geogrid fabric shall be installed, when required.

The fabric shall be placed on approved surfaces only. The use of neets and soil nails as required depending on slopes and soil types.

410.03.7 Gabions

410.03.7.01 Each gabion basket shall be assembled by binding together all vertical edges with wire ties on approximately 150mm spacing or by use of a continuous piece of connecting wire stitched around the vertical edges with a coil every 100 mm.

410.03.7.02 Empty gabion units shall be installed to line and grade as shown on the Drawings. Wire ties or connecting wire shall be used to join the units together in the same manner as described for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure. A standard fence stretcher, chain fall, or iron road may be used to stretch the wire baskets and hold alignment.

410.03.7.03 The gabions shall be filled with riprap as specified, placed by hand or machine to assure alignment and avoid bulges with minimum voids. Alternate placing of rock and connection wires shall be performed until the gabion is filled. After filling with riprap, the lid shall be bent over until it meets the sides and edges and shall be secured to the sides, ends and diaphragms with wire ties or connecting wire in the manner described for assembling.

410.04 Measurement and Payment for Slope Protection and Stabilization Items

410.04.1 Measurement

- a. Loose Riprap, Filter Material, Wire Fabric Enclosed Riprap and Gabions for Slope Protection, shall be measured by cubic meter furnished, installed, completed and accepted. Dimensions shall be as shown on the Drawings.
- b. Grouted Riprap for Slope Protection shall be measured by Square meter furnished, installed, completed, and accepted for the specified layer thickness. Dimensions shall be as shown on the Drawings.
- c. Geogrid Fabric for Slope Protection shall be measured by square meter furnished, laid completed and accepted.
- d. Wire Mesh for Slope Protection and Construction Fabric shall be measured by square meter furnished, installed, completed and accepted.
- e. Excavation, backfilling, slope surface preparation, wire fabric for enclosing riprap and other ancillary 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 Pay Items.

410.04.2 Payment - Payment for slope protection and stabilization items shall be at the rate included in the Bill of Quantities, which shall include all labour, equipment, tools and incidentals to complete the work.

410.05 Cut and Slope Faces Shoring (Upholding Systems):

410.05.1 Scope

The extent of works related to construction of upholding systems shall include the temporary and permanent upholding of slopes, and other areas of cut faces resulting from general and structural excavation works, only at locations where required and approved/or directed by the Engineer.

The intended shoring systems shall be designed, fabricated, supplied, provided, and installed by the Contractor or any other specialist or sub-contractor with ample experience in the excavation upholding field.

The intended shoring systems shall have enough strength and shall be designed to withstand the various types of loads whether applied at present or anticipated in the future, to ensure that the sides of excavation remain intact, stable, safe and presenting no harm or danger to persons who may be available in the considered areas. The shoring systems shall also avoid the occurrence of any damage, whatsoever, to objects, vehicles, and properties falling in adjacent areas to the slopes and faces of cut works.

410.05.2 Qualifications of the contractor's team and/or the subcontractor for Execution of shoring systems

The Contractor's team involved in the upholding works whether employed directly by the Contractor or through any subcontractor, assigned by the Contractor and approved by the Engineer to undertake the upholding works of the cut and slope faces, shall have the following qualifications:

- A minimum of five (5) years of experience in the design and execution of successful cut and slope faces for the shoring systems.
- The proposed personnel for the shoring works should have been working on similar upholding jobs for a minimum of five (5) years.

410.05.3 Contractor's Submittals

Unless otherwise pre-specified in the Contract Documents, the Contractor's proposal for shoring systems shall be submitted for the Engineer's approval and shall include, but without limitation, the following:

- Detailed description of proposed system(s)
- Records of past experience of subcontractor's personnel or any other team assigned by the Contractor and approved by the Engineer to conduct the works. Records of previous experience are to be duly authenticated by the previous employers.
- The design codes and regulations followed throughout the preparation of the design.
- Design related data including, at minimum, the following:
 - Design states
 - Selected design state and situations
 - Earth pressure profiles
 - Type of selected earth retaining structures
 - Elements of shoring structures and related strengths requirements, and materials specifications.
- Detailed design calculations including computer calculations input and output files.

- Soil and rock parameters used in relation to any soil report conducted in the relevant areas of the site of works.
- Detailed shop drawings.
- Materials data sheets issued by the relevant manufacturer.
- Testing certification issued by third party testing agency confirming all properties included in the materials data sheets.
- List of qualified personnel from the Contractor's team, or the sub-contractor's team, shoring system manufacturer's team who shall be involved in the design and/or execution of the works.

410.05.4 Contractor's Liability

Unless otherwise pre-specified in the Contract Documents, the shoring system shall be selected and designed by the Contractor, and submitted for the Engineer's approval prior to execution of works. The Engineer's approval for the proposed system of shoring works shall not release the Contractor from any responsibility or liability resulting from the occurrence of any damage to any person and/or public or private property.

The Contractor shall keep the side of the Employer (owner) free of any responsibility or claim that may arise as a result of improper design and/or execution of the cut and slope faces upholding systems works.

410.05.5 Cut and Slope Faces Upholding Systems:

The upholding systems that may be selected and proposed by the Contractor shall include, but without limitation, the following:

- In-situ concrete and pile walls
- Reinforced and prestressed concrete sheet piles
- Shoring structures consisting of single element or combined elements such as the following:
 - Rock bolts,
 - Rock dowels,
 - Wailing beams,
 - Anchorages,
 - Soil nailing,
 - Shotcrete.
- Others etc. as may be applicable and proposed by the Contractor for the Engineer's approval.

The design, composition, installation, execution, and testing of the above mentioned elements shall be in accordance with the codes and standards approved by the engineer, including the following sections of the FHWA-U.S. Department of Transportation (Federal Highway Administration):

- For rock bolts: Section 259
- For rock dowels: Section 261
- For soil retaining wall: Section 259
- For shotcrete works: Section 566

410.05.6 Measurement and Payment

410.05.6.1 Measurement - Shoring system (upholding) should be measured by square meter and retaining pylon as a lump sum item.

410.05.6.2 Payment - Payment for shoring system and retaining pylons shall be at the rate included in the Bill of Quantities, which shall include all labour, equipment, tools and incidentals to complete the work.

**** END OF SECTION ****

SECTION – V
SUB - BASE AND BASE COURSES

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SECTION – V

SUB - BASE AND BASE COURSES

500 – GENERAL

500.01 **Scope** - This section contains the Materials, Equipment and Construction requirements for Aggregate Sub-Base and Base Courses.

500.02 **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 or Magnesium Sulphate
C 131	Tests Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
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 4318	Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils

AASHTO

T 89	Determining the Liquid Limit of Soils
T 90	Determining the Plastic Limit and Plasticity Index of Soils
T 96	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
T 104	Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
T 180	Moisture-Density Relations of Soils, Using a 10lb Hammer and an 18in Drop
T 191	Density of Soil in-Place by the Sand-Cone Method
T 193	The California Bearing Ratio
T 205	Density of Soil in-Place by the Rubber-Balloon Method

501 – CONTROL OF MATERIALS FOR SUB-BASE AND BASE COURSES

501.01 **Sources of Materials** - The materials used in the work shall meet all quality requirements of the Contract. All materials shall be tested and approved before use. The Contractor shall notify the Engineer of the sources of materials and the Engineer shall approve the sources prior to delivery of materials to the site. Where a source of material does not meet Specification requirements, the Contractor shall furnish material from other sources. Delivery of materials produced from commercial manufacturing processes shall be accompanied by the manufacturer's certification and test report showing the materials comply with the Specification requirements.

501.02 Storage and Handling of Materials - Materials shall be so stored and handled as to assure the preservation of their quality and fitness for the Work. Materials, even though approved before storage or handling, may again be inspected and tested prior to use in the work. Stored material shall be located so as to facilitate their prompt inspection. All storage sites shall be restored to their original condition at the Contractor's expense prior to acceptance of the works.

Handling and stockpiling of aggregates shall at all times be such as to eliminate segregation or contamination of the various sizes. Stockpiles shall be kept flat and the formation of high cone-shaped piles shall not be permitted. When conveyor belts are used for stockpiling aggregates, the Engineer may require the use of bafflechutes or perforated chimneys.

When trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile and their use shall be limited to levelling the deposited material only.

The Contractor shall take all necessary protection measures in the storage, handling and stockpiling of materials to prevent contamination of materials. The measures that the Contractor proposes to take shall be subject to the approval of the Engineer.

501.03 Inspection, Testing and Control of Materials - The Engineer will at all times have access to all portions of the aggregate plant, storage yards, crushers and other facilities used for producing and processing the materials of construction. The Engineer shall have authority to request samples and tests of any material supplied to the site from any source whatsoever in order to establish their compliance with Specifications and to accept or reject as he deems necessary. Samples shall also be taken from completed work to determine compliance with the Specifications. The frequency of all sampling and testing shall be in accordance with these Specifications and / or as directed by the Engineer.

501.04 Unacceptable Materials - Materials that do not conform to the requirements of the Specifications shall be rejected and removed immediately from the site of the works unless otherwise instructed by the Engineer. No rejected materials, the defects of which have been corrected, shall be used until approval has been given by the Engineer.

501.05 Test Methods - Test methods shall comply with the specified requirements.

501.06 Water - Sea water shall not be used for spreading and compacting operations for aggregate sub-base and base courses.

502 – MAJOR EQUIPMENT USED FOR SUB-BASE AND BASE COURSES

502.01 General Requirements - Unless otherwise stipulated herein, all the provisions of these Specifications in respect of specifications for the main machinery and tools utilised in the Earthworks construction, shall be adhered to, all subject to the following modifications and additions:

502.02 Spreaders - Spreaders shall be self-propelled and shall be capable of spreading the sub-base and base materials in one operation so as to make it ready for compaction with minimum shaping. The spreader shall be provided with a screed that strikes off and distributes the material to the required width and level. The width of each spread shall not be less than a traffic lane wide. The screed shall be adjustable to the required cross-section. Screed action includes any practical motion that produces a finished surface texture of uniform appearance.

502.03 Travel Mixers - Travel Mixers shall be of a type which are capable of mixing to the full depth of the layer thickness being processed, by picking up the material, mixing, agitating or otherwise blending into a homogeneous mass which conforms to the required general gradation and other specifications. Mixers shall be equipped with an accurate depth control device to avoid the disturbance of previously accepted layers. After mixing, the material shall be deposited by the mixer in its final position so that prior to compaction no spotting, picking-up or otherwise shifting the material will be required. Mixers may be equipped with pressure spray bars which can supply a uniform distribution of metered water during the mixing process.

502.04 Central Mixers - A central mixing plant shall be either of an approved drum or pugmill type with a moisture control system so that the material may be spread without further mixing or processing.

502.05 Rollers - Rolling equipment shall consist of steel wheeled rollers and pneumatic-tyred rollers all as specified in these Specifications. A minimum of three rollers shall be required at all times, one self-propelled pneumatic-tyred and two steel wheeled rollers. As many additional rollers shall be used as necessary to provide the specified density and surface characteristic in an orderly, efficient and continuous manner. Tandem steel wheeled rollers shall be of such weight that, under working conditions, will develop contact pressure adequate to obtain the required density.

502.06 Unacceptable Equipment - The Engineer shall have the right to stop the use of any equipment or plant which he deems to be inferior to the quality required and to instruct the removal of such equipment and to have it replaced by suitable equipment or to alter the method of operation at any time he so desires.

The Contractor shall immediately comply with such instructions without being entitled to any indemnities or extensions as a result of such instructions. The Contractor shall not be allowed to use any equipment or plant before obtaining the approval of the Engineer and the Contractor shall undertake to follow sound technical methods in operation and to engage skilled and trained operators, mechanics and

labour to carry out the works. The Engineer shall have the right to expel any operators, mechanics or labour and to instruct suitable replacement thereof at any time he deems such action is necessary.

503 – AGGREGATE SUB-BASE AND BASE COURSES

503.01 General Requirements

503.01.1 Description - Aggregate sub-base and base courses shall be in compliance with ASTM D2940 and shall consist of crushed mineral aggregates or natural mineral aggregates of the gradation and thickness indicated in the Specifications and on the Drawings.

503.01.2 Natural Aggregate Sub-Base and Base Courses - shall consist of coarse and fine mineral aggregates which have been screened and blended to the various gradings and constructed to the thickness as indicated on the Drawings and in the Specifications.

503.01.3 Crushed Aggregate Sub-Base and Base Courses - shall consist of crushed coarse aggregate and crushed or natural fine aggregate screened and blended in accordance with the required gradation and constructed to the thicknesses as indicated on the Drawings and in the Specifications.

503.02 Materials Requirements for Aggregate Sub-Base and Base Courses

503.02.1 Fine Aggregates Used for Aggregate Sub-Base and Base Courses –

Fine aggregate passing the No.4 (4.75mm) sieve shall normally consist of fines from the operation of crushing the coarse aggregate; where available and suitable, natural sand or finer mineral matter, or both, may be added. The fraction of the final mixture that passes the No. 200 (75µm) sieve shall not exceed 60% of the fraction passing the No. 30 (600µm) sieve. The fraction passing the No. 40 (425-µm) sieve shall have a liquid limit no greater than 25 and shall not have a plasticity index greater than 4. The sand equivalent value of the fine aggregate shall be no lower than 35.

503.02.2 Coarse Aggregates Used for Aggregate Sub-Base and Base Courses – Coarse aggregate retained on the No.4 (4.75mm) sieve shall consist of durable particles of crushed stone, gravel, or slag capable of withstanding the effects of handling, spreading and compacting without degradation productive of deleterious fines. Of the particles which are retained on a 3/8 –in (9.5 mm) sieve, at least 75% shall have two or more fractured faces.

503.02.3 Types of Aggregate Sub-Base and Base Courses - The combined gradation including fine and coarse aggregates shall conform to the gradation for Sub-Base and Base Courses as indicated in the following Table. The continuous smooth gradation of materials used shall be kept within the specified gradation limits and gap grading must be avoided.

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

The base material shall have a 4-day soaked CBR of not less than 80% when compacted at 100% modified Proctor (AASHTO T 180-D) and tested in accordance with AASHTO T 193.

Sieve Size: (square openings)	Design Range (weight percentages passing)		Job Mix Tolerances (weight percentages passing)	
	<u>Bases</u>	<u>Sub-bases</u>	<u>Bases</u>	<u>Sub-bases</u>
2 in. (50mm)	100	100	-2	-3
1-1/2 in. (37.5mm)	95-100	90-100	± 5	+5
3/4 in. (19.0mm)	70-92	-	±8	-
3/8 in. (9.5mm)	50-70	-	±8	-
No.4 (4.75 mm)	35 - 55	30 - 60	±8	±10
No.30 (600 µm)	12-25	-	± 5	-
No.200 (75 µm)	0 - 8	0 - 12	± 3	± 5

503.03 Construction Requirements for Aggregate Sub-Base and Base Courses

503.03.1 Finished Sub-grade Levels - Prior to commencing the construction of the sub-base and base courses, it is necessary to make sure that the sub-grade conforms to the specifications and is compacted to the maximum Dry Density as indicated in these specifications and that the surface thereof conforms to the levels and slopes indicated in the Drawings. In all cases the approval of the Engineer must be obtained before commencing spreading for the sub-base and bases courses.

503.03.2 Screening and Mixing of the Materials - Screening shall be required for the materials used in aggregate sub-base and base courses. Screens shall be of the size and number required to remove oversize aggregate and, if necessary, to separate the materials into two or more fractions so that they may be combined to meet the required gradation. When conveyor belt samples from the end of the screening and/or crushing-screening operation yield a product consistently within the specified gradation, no further mixing shall be required and the material may be loaded and hauled directly to the road. If stockpiled, it shall be stockpiled so as to prevent segregation.

Mixing of material can be achieved through the use of the central mixing plant or travel mixer. Where separate size materials are to be blended to meet the gradation, such blending shall be as directed by the Engineer and shall be accomplished prior to delivery to the roadway. Mixing of separate materials on the roadway by motor grader will not be permitted.

503.03.3 Spreading and Compacting - After carrying out the screening and mixing of aggregate material, samples of the approved material shall be taken in order to determine the optimum Moisture Content.

Material shall then be spread on the road surface to thicknesses that would result in layers not more than 250mm thick after compaction.

The natural moisture content of materials constituting the sub-base and base courses shall be determined. If the natural moisture content is less than the optimum moisture content, the necessary amount of water must be added to obtain the optimum content allowing for the quantity which may be lost by evaporation in the process of raking, levelling and compacting, depending on atmospheric temperature, quantity of material and the equipment and plant to be used in this operation, provided that the layer shall be compacted when the moisture

content therein is within $\pm 2\%$ of the optimum moisture content in order to obtain Maximum Dry Density and the moisture content is uniform in all parts of the section where the work is being carried out and in the various depths of the layer thickness.

Compaction shall start immediately thereafter, by means of pneumatic and steel rollers or vibratory rollers and in accordance with the instructions of the Engineer.

Compaction must start with rollers from extreme sides proceeding gradually toward the road axis. Rolling must continue until the in-situ dry density is not less than 100% of the Maximum Dry Density as determined by the Moisture-Density Relationship Test AASHTO T 180.

503.03.4 Multi-Layers - During all the above-mentioned operations of mixing, spreading, compacting and levelling of sub-base and base courses material, care must be taken so that layers already compacted under the layer being executed are not affected, or that the finished sub-grade or base surface is also not affected. This aspect must be given special attention in places where equipment makes turns in going back and forth and any such damage resulting in mixing the various layers constituting the different sub-grades and base courses shall be carefully made good by the Contractor at his own expense and to the satisfaction of the Engineer.

If more than one sub-base or base course is required for reaching the required thickness described in the Specifications, each such course will be constructed as hereinbefore described.

Where the finished compacted thickness indicated on the drawings exceeds 200 mm, placing shall be executed in composite layers each layer not exceeding 250 mm in compacted thickness as directed by the Engineer.

503.03.5 Protection of Surface - The Contractor shall protect the sub-base or base course so that it shall be maintained sound during work progress, after its completion and prior to receiving the bituminous layers or prior to laying the surface overlay thereon. Any damage caused to the layer if exposed to traffic or natural conditions resulting in damage to its surface shall be made good at the expense of the Contractor and to the satisfaction of the Engineer.

When the rolling develops irregularities, the irregular surface shall be loosened, then refilled with the same kind of material as used in constructing the course and again rolled according to specifications. Along places inaccessible to rollers, the sub-base and base courses' material shall be tamped thoroughly with mechanical tampers.

Work on the sub-base and base courses shall not be permitted during rainy weather.

Hauling equipment may be routed over the completed portion of the sub-base and base courses provided no damage results and provided that such equipment is routed over the full width of the course to avoid rutting or uneven compaction.

The Engineer has the right to stop all hauling over completed or partially completed sub-base and base courses when in his opinion such hauling is causing damage.

503.03.6 Preparing the Surface Before Priming - Following the completion of the courses the Contractor shall perform all maintenance work necessary to keep the course in a condition for priming. The prime coat shall be applied after preparation of the previously compacted surface, all in accordance with these Specifications.

503.03.7 Testing and Acceptance of Aggregate Sub-Base and Base Courses - Prior to the application of any prime coat or any other paving course, the aggregate sub-base and/or base course shall have been tested and accepted by the Engineer. The following shall be adhered to in accepting completed aggregate sub-base and base courses:

- a. **Strength Specification for Compacted Aggregate Sub-Base and base courses** - The aggregate sub-base and base courses shall be compacted and tested for acceptance in accordance with the compaction requirements of these Specifications.
- b. **Requirements for Compaction** - Wherever the degree of compaction is found to be less than the 100% specified, the area of sub-base or base course involved shall be satisfactorily corrected so that the specified density is achieved.
- c. **Requirements for Gradation** - Wherever the gradation is found to be outside the limits specified, the area of sub-base and/or base course involved shall be scarified, removed or otherwise reworked as directed by the Engineer to provide a material within specification limit.
- d. **Requirements for Thickness** - Wherever the thickness of compacted aggregate sub-base or base courses is found to vary from the plan thickness by more than 10% the area involved shall be satisfactorily corrected to provide the required thickness constructed to the specified grade level.
- e. **Requirements for Evenness of Surface and Grade Level** - The final surfaces of the sub-base or base course shall be tested by means of a 4 metre long straight edge and no rises or depressions in excess of 10mm shall appear in the surface. Likewise the finished surface shall be constructed to the specified grade levels to within 10mm.

Where these requirements are not met, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the course by scarifying to a minimum depth of 75mm or 4 times the maximum particle size, whichever is the greater, reshaping by adding or removing material as necessary and recompacting in accordance with the specifications.

503.04 Measurement and Payment for the Aggregate Sub-base and Base Courses

503.04.1 Measurement - Measurement of aggregate sub-base and base courses shall be by metre cube in place for the various types required in accordance with the Drawings, Specifications or as directed by the Engineer and shall be calculated from the top surface area, excluding tapered edges which shall be included in the rate.

503.04.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include for, but not by way of limitation, all labour, tools, plant, materials, transport, preparation and compaction of the sub-grade to the levels indicated on the drawings, mixing, screening, spreading, rolling and compaction, shaping and levelling,

testing etc. and for everything necessary for the proper completion of the work in accordance with the Drawings, Specification and instruction of the Engineer.

Where new road construction work adjoins or meets existing road construction, e.g. new shoulders and cross-roads, no separate payment will be made for cutting back the edges of the existing construction to receive new sub-base or base layers, the cost being deemed to be included with the cost of the new sub-base or base courses.

**** END OF SECTION ****

SECTION VI: ASPHALT WORKS

SECTION VI: BITUMINOUS CONSTRUCTION

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REFERENCE STANDARDS AND SPECIFICATIONS

AASHTO M17	Standard Specification for Mineral Filler for Bituminous Paving Mixtures
AASHTO M20	.....	Standard Specification for Penetration-Graded Asphalt Cement
AASHTO M81	.....	Standard Specification for Cutback Asphalt (Rapid-Curing Type)
AASHTO M82	.....	Standard Specification for Cutback Asphalt (Medium-Curing Type)
AASHTO M85	.....	Standard Specification for Portland Cement
AASHTO M140	.....	Standard Specification for Emulsified Asphalt
AASHTO M156	.....	Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO M208	.....	Standard Specification for Cationic Emulsified Asphalt
AASHTO M316	.....	Standard Specification for Polymer-Modified Emulsified Asphalt
AASHTO M320	.....	Standard Specification for Performance-Graded Asphalt Binder
AASHTO M332	.....	Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test
AASHTO MP2	.....	Standard Specification for Superpave Volumetric Mix Design
AASHTO R28	.....	Standard Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
AASHTO T11	.....	Materials Finer Than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T27	.....	Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
AASHTO T30	.....	Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T40	.....	Standard Method of Test for Sampling Bituminous Materials
AASHTO T44	.....	Standard Method of Test for Solubility of Bituminous Materials
AASHTO T48	.....	Standard Method of Test for Flash Point of Asphalt Binder by Cleveland Open Cup
AASHTO T96	.....	Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T104	.....	Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
AASHTO T112	.....	Standard Method of Test for Clay Lumps and Friable Particles in Aggregate

AASHTO T113	.....	Standard Method of Test for Lightweight Pieces in Aggregate
AASHTO T164	.....	Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
AASHTO T166	.....	Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
AASHTO T182	.....	Standard Method of Test for Coating and Stripping of Bitumen-Aggregate Mixtures
AASHTO T194	.....	Standard Method of Test for Determination of Organic Matter in Soils by Wet Combustion
AASHTO T240	.....	Standard Method of Test for Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
AASHTO T245	.....	Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus
AASHTO T278	.....	Standard Method of Test for Surface Frictional Properties Using the British Pendulum Tester
AASHTO T279	.....	Standard Method of Test for Accelerated Polishing of Aggregates Using the British Wheel
AASHTO T302	.....	Standard Method of Test for Polymer Content of Polymer Modified Emulsified Asphalt Residue and Asphalt Binders
AASHTO T304	.....	Standard Method of Test for Uncompacted Void Content of Fine Aggregate
AASHTO T313	.....	Standard Method of Test for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
AASHTO T314	.....	Standard Method of Test for Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT)
AASHTO T315	.....	Standard Method of Test for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
AASHTO T316	.....	Standard Method of Test for Viscosity Determination of Asphalt Binder Using Rotational Viscometer
ASTM C88	.....	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate
ASTM C127	.....	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C128	.....	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131	.....	Standard Test Method for Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	.....	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C183	.....	Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement

ASTM C207	.....	Standard Specification for Hydrated Lime for Masonry Purposes
ASTM D5	.....	Standard Test Method for Penetration of Bituminous Materials
ASTM D36	.....	Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
ASTM D75	.....	Standard Practice for Sampling Aggregates
ASTM D92	.....	Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D113	.....	Standard Test Method for Ductility of Bituminous Materials
ASTM D140	.....	Standard Practice for Sampling Bituminous Materials
ASTM D242	.....	Standard Specification for Mineral Filler for Bituminous Paving Mixtures
ASTM D402	.....	Standard Test Method for Distillation of Cutback Asphaltic (Bituminous) Products
ASTM D423	.....	Method of Test for Liquid Limit of Soils
ASTM D424	.....	Standard Method of Test for Plastic Limit
ASTN D692	.....	Standard Specification for Coarse Aggregate for Bituminous Paving Mixtures
ASTM D946	.....	Standard Specification for Penetration Graded Asphalt Cement for Use in Pavement Construction
ASTM D1075	.....	Standard Test Method for Effect of Water on Compressive Strength of Compacted Bituminous Mixtures
ASTM D2026	.....	Standard Specification for Cutback Asphalt (Slow-Curing Type)
ASTM D2042	.....	Standard Test Method for Solubility of Asphalt Materials in Trichloroethylene
ASTM D2170	.....	Standard Test Method for Kinematic Viscosity of Asphalts
ASTM D2171	.....	Standard Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer
ASTM D2172	.....	Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D2399	.....	Standard Practice for Selection of Cutback Asphalts
ASTM D2419	.....	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D3143	.....	Standard Test Method for Flash Point of Cutback Asphalt with Tag Open-Cup Apparatus
ASTM D3625	.....	Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water
ASTM D4318	.....	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM D4402	.....	Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer
ASTM D4791	.....	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	.....	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6926	.....	Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus
ASTM D6927	.....	Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures

SECTION 6.01 MATERIALS FOR BITUMINOUS CONSTRUCTION

6.01.01 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 or performance graded bitumens, cutback bitumens, emulsified bitumens and modified bitumens for use in bituminous courses and surface treatments.

B. All material sources proposed for use in the Works shall be approved prior to procuring or processing material from such sources. Materials used in the Works shall be tested and approved before use. 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 these Specifications - Materials. Materials shall be stored on hard, clean surfaces.

6.01.02 AGGREGATE MATERIALS GENERAL

A. Sources and Production

A.1 The Contractor shall demonstrate recognition of 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 the 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 these Specifications - Samples and Approval 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 Specifications 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 a third-party 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.

6.01.03 AGGREGATES FOR BITUMINOUS PAVING MIXES

A. General

A.1 Aggregates for use in bituminous base course, leveling course, macadam and cold mix courses shall consist of crushed rock or crushed gravel. Aggregates for use in wearing courses shall consist of 100% crushed rock.

A.2 Aggregates shall not contain more than 1% gypsum.

B. Coarse Aggregates

B.1 Coarse aggregate shall be the fraction of crushed aggregate material retained on the 4.75 mm (No. 4) sieve.

B.2 Crushing shall result in a product such that 100% by weight shall have at least one fractured face, and at least 90% by weight shall have 2 or more fractured faces.

B.3 Aggregates shall not contain more than 5% chert by weight.

B.4 Aggregate particles shall be clean, and reasonably free of deleterious substances such as: clay lumps, alkali, salt, and organic materials. The maximum permissible amounts of these harmful substances are listed below:

SUBSTANCE	STANDARD	MAXIMUM ALLOWED % by weight
Coal and lignite	AASTHO T113	1.0
Clay lumps, friable particles, and deleterious material	AASHTO T112	1.0
Organic materials	AASHTO T194	0.03

B.5 Aggregate particles shall be clean, hard, durable and sound. The physical characteristics of the coarse aggregate shall comply with ASTM D692.

B.6 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.

B.7 Aggregates shall comply with the following Standards and limits:

TEST	STANDARD	LIMIT		
		Limestone	Basalt	Other
Fractured particle in coarse aggregate One face – (%)	ASTM D5821	For Marshall Mixes: 90% minimum For Superpave Mixes: Refer to Section 6.03.03		
Soundness Using Sodium Sulphate (5 cycles)	ASTM C88	12% maximum 9% maximum on sites over 1000m above sea level	6% maximum	12% maximum 9% maximum on sites over 1000m above sea level
Soundness Using Magnesium Sulphate (5 cycles)	ASTM C88	18% maximum, 14% maximum on sites over 1000m above sea level	9% maximum	18% maximum, 14% maximum on sites over 1000m above sea level
Degradation (Loss by abrasion)	ASTM C131	30% maximum	20% maximum	20% maximum
Water Absorption	ASTM C127	2% maximum	2% maximum	2% maximum
Resistance to Stipping	ASTM D3625/3625M	95% minimum	95% minimum	95% minimum
Flakiness and Elongation (5:1 aspect ratio) OR Flakiness Index	ASTM D4791 BS EN933-3	10% maximum 25% maximum	10% maximum 25% maximum	10% maximum 25% maximum
Polish Stone Value	AASHTO T278 & T279	40 minimum	45 minimum	45 minimum

B.8 For the asphalt wearing course with aggregate mixes including basalt aggregates in addition to the limestone aggregates, the several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the proportions of basalt and the limestone in the coarse fraction of the aggregates meet the following grading requirement:

The aggregate mix shall comprise of 48% basalt and 52% limestone for coarse aggregate portions only.

No basalt is required in the fine aggregate or mineral filler.

C. Fine Aggregates

C.1 Fine aggregates shall be the fraction of crushed aggregate material passing the 4.75 mm (No. 4) sieve. Fine aggregate shall consist of natural sand or manufactured fine aggregate such as crushed stone and crushed gravel.

C.2 The percentage by weight of friable particles, clay lumps, and other deleterious material shall not exceed 0.3% as determined by AASHTO T112.

C.3 Fine 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.

C.4 The physical characteristics of fine aggregates shall comply with the following Standards and limits:

TEST	STANDARD	LIMIT
Liquid Limit	ASTM D4318	25% maximum
Plasticity Index	ASTM D4318	Non-plastic
Sand Equivalent	ASTM D2419	For Marshall Mixes: 40% minimum For Superpave Mixes: Refer to Section 6.03.03
Water Absorption	ASTM C128	1.0% maximum
Angularity	AASHTO T304 Method A	40% minimum

D. Mineral Fillers

D.1 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.

D.2 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.

6.01.04 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 SO₃) 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 and 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 T113.

E. Aggregates shall be washed or processed by an approved 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 6.1.2.

Table 6.1.2: 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.

6.01.05 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 in accordance with ASTM D140 or a comparable device acceptable to the Engineer.

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°C to +60°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°C above the maximum application temperature specified nor above 170°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°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 these specifications: Samples and Approvals.

6.01.06 BITUMEN PRODUCTS

A. Penetration Graded Bitumen

A.1 The binder type shall be classified according to ASTM D946/D946M, as shown in Table 6.1.3.

TABLE 6.1.3: PROPERTIES OF PENETRATION GRADE BITUMEN

		Penetration Grade					
		40 -50		60 - 70		85 - 100	
Test	Standard	Min	Max	Min	Max	Min	Max
Original Binder							
Ductility at 25°C (cm)	ASTM D113	100	-	100	-	100	-
Penetration at 25°C (0.1 mm)	ASTM D5	40	50	60	70	85	100
Softening Point (° C)	ASTM D36	52	-	49	-	45	-
Solubility in Trichloroethylene (% wt)	ASTM D2042	99	-	99	-	99	-
Flashpoint (Cleveland Open Cup.) (°C)	ASTM D92	230	-	230	-	230	-
Thin Film Oven Residue							
Penetration of residue (% of original)	ASTM D5	55	-	52	-	47	-
Ductility at 25°C - 5cm/min (cm)	ASTM D113	-	-	50	-	75	-

A.2 Sampling and testing shall be in accordance with the AASHTO standard method listed in AASHTO M 20-70. The penetration and softening point tests shall be tested once every 75 tons of asphalt concrete per layer. The remaining tests shall be performed once every 450 tons of asphalt concrete per layer.

A.3 The binder penetration grade shall conform to the following grading map of Lebanon:



B. Performance Graded Bitumen

B.1 The PG grade selection is dependant of the climate and traffic as described in Asphalt Institute MS-26 and shall meet the requirements of AASHTO M320 and M332.

B.2 The base binder PG grade shall conform to the following PG grading map of Lebanon:



B.3 A one-grade increase, equivalent to 6°C, shall be applied to the base high-temperature PG grade in cases of slow traffic (between 20 km/h and 70 km/h) or standing traffic (<20 km/h). Over and above, a one-grade increase shall be applied to the base high-temperature where traffic volume exceeds 10 million ESALs as specified in Table 6.1.4.

TABLE 6.1.4: ADJUSTMENTS FOR HIGH TEMPERATURE GRADE FOR TRAFFIC CONSIDERATIONS

EXISTING CONDITION	HIGH-TEMPERATURE GRADE ADJUSTMENT
Slow/Standing Traffic	+ 1 Grade (6°C)
Traffic Volume Exceeds 10 Million ESALs	+ 1 Grade (6°C)

B.4 PG Binders shall be tested in accordance with the latest version of AASHTO M 320 and the material shall conform to the following requirements:

Test	Standard	Specification Range
Original Binder		
Solubility in Trichloroethylene (%)	AASHTO T44	Min 99%
Flash Point (°C)	AASHTO T48	Min 230°C (450°F)
Viscosity (Brookfield) at 135° C, max °C	AASHTO T316	Max 3 Pa.s
Dynamic shear ($G^*/\sin\phi$) at 10 rad/s	AASHTO T315	Min 1 KPa
Phase Angle (ϕ)	AASHTO T315	Max 75°
Rolling Thin Film Oven Residue (AASHTO T 240)		
Mass change (%)	AASHTO T240	Max 1%
Dynamic shear ($G^*/\sin\phi$) at 10 rad/s	AASHTO T315	Min 2.2 Pa.s
Pressurized Aging Vessel Residue (AASHTO R28)		
Dynamic Shear ($G^*\sin\phi$) at 10 rad/s	AASHTO T315	Max 5000 KPa
Creep at 60 seconds: -Stiffness, S -m Value	AASHTO T313	-Max 300 MPa -Min 0.3
Direct Tension at 1 mm/min failure strain	AASHTO T314	Min 1%

B.5 If the creep stiffness is below 300 MPa, the direct tension test can be skipped. If the creep stiffness is between 300 and 600 MPa, the direct tension can replace the creep stiffness.

B.6 For unmodified binder, the mixing and compaction temperature ranges shall be those corresponding to viscosity ranges of 0.17+/- 0.02 Pa-s and 0.28+/- 0.03 Pa-s, respectively, as determined from viscosity vs. temperature curves (ASTM D4402).

B.7 Sampling and testing shall be in accordance with ASTM D6373. The binder grading tests shall be tested once every 75 tons of asphalt concrete per layer. The remaining tests shall be performed once every 450 tons of asphalt concrete per layer.

C. Polymer Modified Bitumen (PMB)

C.1 A high-temperature PG Grade of 76 or greater will require addition of modifier such as SBS (Styrene Butadiene Styrene) or similar. The Contractor shall submit a Method Statement for the preparation of PMB blending including the type of polymer intended for use to the Engineer's approval, and shall demonstrate through testing that the modified asphalt meets all the specification requirements and AASHTO M320 specifications.

C.2 The modified bitumen shall be tested for compatibility with the polymer modifier to ASTM D7173 for both Softening Point and DSR. The difference in °C between the softening points of the respective top and bottom portions of the tube sample shall not exceed 4°C. The separation ratio based on G^* shall have an average G^* value $[(Top + Bottom)/2]$ within 0.8 to 1.2 of the initial G^* value.

C.3 The mixing and compaction temperatures shall be established in the laboratory by determining the Brookfield viscosity of the approved Polymer Modified Bitumen at three different temperatures 135° C, 165° C and 195° C. The established mixing and compaction temperatures shall then be evaluated and finalized based upon successful site trials. The mixing temperature shall not exceed 180° C.

C.4 The optimal polymer content in asphalt binder shall be determined based on laboratory trial blends according to AASHTO T302 and shall satisfy the range of 2 to 5% by mass of binder.

C.5 The mixing and preparation of modified bitumen shall be carried out in accordance with the manufacturers' instructions, and with the approval of the Engineer. The modifier shall be pre-blended into the conventional bitumen before mixing with the aggregate in the hot mix plant. Blending temperature shall not exceed that set by the manufacturer.

C.6 The production of the modified bitumen shall require a high shear blending system to ensure complete and controlled dispersion and chemical reaction of the modifiers with the conventional bitumen. The Contractor shall ensure proper circulation and agitation during storage to avoid separation of the modifier from the base bitumen.

D. Rapid-Curing (RC) Cutback Bitumen

D.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 6.1.5.

D.2 Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 81.

D.3 RC cutback bitumen spraying temperature ranges shall be as follows:

RC Cutback Bitumen Grade	Spraying Temp °C
RC - 70	40 - 75
RC - 250	65 - 105
RC - 800	90 - 115
RC - 3000	105 – 135

E. Medium-Curing (MC) Cutback Bitumen

E.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 6.1.6.

E.2 Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 82.

E.3 MC cutback bitumen spraying temperature ranges shall be as follows:

MC Cutback Bitumen Grade	Spraying Temp °C
MC - 30	21 - 63
MC - 70	45 - 80
MC - 250	70 - 110
MC - 800	95 - 125
MC - 3000	110 – 145

F. Slow-Curing (SC) Cutback Bitumen

F.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 6.1.7.

F.2 Sampling and testing shall be in accordance with the appropriate ASTM standard methods.

F.3 SC cutback bitumen spraying temperature ranges shall be as follows:

SC Cutback Bitumen Grade	Spraying Temp °C
SC – 70	45 - 80
SC -250	70 - 110
SC - 800	95 - 125
SC - 3000	110 – 145

TABLE 6.1.5: 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°C centistokes ASTM D2170	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open-cup) °C ASTM D3143	-	-	27	-	27	-	27	-
Water, %	-	0.2	-	0.2	-	0.2	-	0.2
Distillation Test: ASTM D402								
Distillate, % by volume of total distillate to 360°C								
- to 190°C	10	-	-	-	-	-	-	-
- to 225°C	50		35	-	15	-	-	-
- to 260°C	70		60	-	45	-	25	-
- to 315°C	85		80	-	75	-	70	-
Residue from distillation to 360°C volume percentage of sample by difference, ASTM D402	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°C poises, ASTM D2171	100	-	100	-	100	-	100	-
Ductility, 5 cm/min. at 25 °C cm, ASTM D113	99	-	99	-	99	-	99	-
Solubility in Trichloroethylene, %, ASTM D2042	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 6.1.6: 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, ASTM D2170	30	60	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open- cup) °C, ASTM D3143	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, ASTM D402										
- 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, ASTM D402	50	-	55	-	67	-	75	-	80	-
Tests on residue:										
Tests on residue from distillation Absolute viscosity at 60°C poises, ASTM D2171	300	1200	300	1200	300	1200	300	1200	300	1200
Ductility, 5 cm/min. at 25 °C cm, ASTM D113	100	-	100	-	100	-	100	-	100	-
Solubility in Trichloroethylene, %, ASTM D2042	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 6.1.7: PROPERTIES OF S.C. CUTBACK BITUMEN

	<u>SC - 70</u>		<u>SC - 250</u>		<u>SC - 800</u>		<u>SC - 3000</u>	
	Min	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity at 60 °C centistokes, ASTM D2170	70	140	250	500	800	1600	3000	6000
Flash Point (Cleveland open-cup) °C, ASTM D92-IP 36	66	-	79	-	93	-	107	-
Distillation test:								
Total distillate to 360°C, volume %, ASTM D402	10	30	4	20	2	12	-	5
Solubility in trichloroethylene %, ASTM D2042	99	-	99	-	99	-	99	-
Kinematic viscosity on distillation residue at 60°C, St, ASTM D2170	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

G. Emulsified Bitumens

G.1 Selection and use of emulsified bitumens shall generally be in accordance with the recommendations in AASHTO M140 or M208 or M 316 for the designated types and grades, subject to the following requirements.

G.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.

G.3 The manufacturer shall furnish samples of the base bitumen used in the emulsion.

G.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.

G.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.

H. Anionic Emulsified Bitumen

H.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 6.1.8.

H.2 Sampling and testing shall be in accordance with AASHTO T 59.

H.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°C, except for Grade RS-2 where the range shall be 50-75°C. The temperature range for pugmill mixing for medium and slow setting types shall be 15-65°C.

I. Cationic Emulsified Bitumen

I.1 Cationic emulsified bitumens shall, prior to dilution, conform to the requirements of AASHTO M 208 or M 316, for Types CSS-1 and as listed in Table 6.1.9.

I.2 Sampling and testing shall be in accordance with AASHTO T 59.

I.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 °C (except for Grade CRS-2 where the range shall be 50-75 °C). The temperature range for pugmill mixing for medium and slow setting types shall be 15-65 °C.

TABLE 6.1.8: 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 6.1.9: PROTECTION OF CATIONIC EMULSIFIED BITUMEN

	Slow-Setting CSS-1		
	Min.		Max.
Tests on emulsions:			
Viscosity, Saybolt Furol at 25°C, s	20		100
Storage stability test, 24-h, %	1		
Particle charge test		Positive	
Sieve test, %			0.15
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		

6.01.07 MEASUREMENT

Items listed in this Section shall be measured as prescribed in the appropriate sections of these Specifications.

SECTION 6.02 BITUMINOUS PRIME AND TACK COATS

6.02.01 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.

6.02.02 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 6.01 - Materials for Bituminous Construction or as specified in the Drawings.

C. Slow-Curing Emulsified Bitumen

Slow-setting cationic/anionic 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 6.01 - Materials for Bituminous Construction or as specified in the Drawings.

6.02.03 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 these Specifications - Contractor's Plant and Equipment.

6.02.04 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.

6.02.05 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 15°C. 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.

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 6.01 - 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

<u>Type of Surface</u>	<u>Litres/ m²</u>
Untreated subgrade surfaces, shoulders base course:	0.75 - 2.0
Bridge wearing surfaces, concrete pavements:	0.3 - 0.6
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 6.03: 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°C.

C.3 The rate of application shall be approved by the Engineer between 0.3 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.

6.02.06 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 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.

PAY ITEM	UNIT OF MEASUREMENT
(6.2.1) Bituminous Prime Coat	Square Metre (m ²)
(6.2.2) Bituminous Tack Coat	Square Metre (m ²)
(6.2.3) Bituminous Prime Coat in temporary diversions	Square Metre (m ²)

SECTION 6.03 BITUMINOUS COURSES

6.03.01 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, leveling courses, macadam courses, cold mix courses and recycled bituminous base course, are specified in the respective sections relating to such courses.

6.03.02 MATERIALS

A. Bituminous mixes shall comprise of coarse and fine mineral aggregate, mineral or cement filler and bitumen with mix additives if specified.

B. All materials shall conform to the relevant requirements of Section 6.01 - Materials for Bituminous Construction.

6.03.03 MIX DESIGN

A. General

A.1 Bituminous concrete mix design shall be conducted based on the Marshall Method of Mix Design (Asphalt Institute Manual Series MS-2) or the Superpave Volumetric Mix Design Method (Asphalt Institute Manual Series SP-2 or AASHTO MP 2).

A.2 Bituminous concrete mix designs shall be performed by the Contractor and verified by the Engineer.

A.3 The bituminous layers of the surface course shall consist of 4 to 7cm thick layers (NMAS 12.5 or 19mm), and those of the bituminous base course shall consist of 7 to 10cm thick layers (NMAS 19 or 25mm). The maximum nominal maximum aggregate size (NMAS) used in the asphalt mix shall depend on the layer thickness as follows:

ASHPAT LAYER THICKNESS (CM)	Maximum NMAS (MM)
4 - 5	12.5
6 - 7	19.0
8 - 10	25.0

B. Marshall Method of Mix Design

B.1 The Marshall Design method shall conform to the requirements of the Asphalt Institute Manual Series MS-2.

B.2 The aggregate gradation when tested in accordance with ASTM C126 shall conform to the gradation shown below. Combined gradations which approach maximum limits on some sieves and minimum limits on other sieves shall be avoided.

AGGREGATE GRADATION FOR BITUMINOUS MIXES

SIEVE SIZE (MM)	% PASSING		
	12.5mm NMA S	19.0mm NMA S	25.0mmNMA S
37.5	100	100	100
25.0	100	100	90-100
19.0	100	90-100	68-90
12.5	90-100	69-90	57-78
9.5	68-90	58-78	49-69
4.75	48-68	40-60	34-56
2.36	33-53	25-45	22-42
1.18	20-40	15-30	13-29
0.600	14-30	10-22	8-21
0.300	9-21	6-15	6-14
0.150	6-10	5-10	4-10
0.075	2-10	2-8	1-7

B.3 The Marshall test procedure requires preparing the mixture in accordance to ASTM D6926. Marshall stability and flow shall comply with ASTM D6927 and AASHTO T245. The Marshall testing machine shall conform with ASTM D6927. The performed rate of loading shall be 2 inch/minute.

B.4 The Marshall Mix design criteria are listed in the table below:

MARSHALL DESIGN CRITERIA FOR BITUMINOUS MIXES

Properties	Bituminous Wearing Course			Bituminous Base Course		
	Low (< 1M ESAL)	Medium (1-5M ESAL)	High (>5M ESAL)	Low (< 1M ESAL)	Medium (1-5M ESAL)	High (>5M ESAL)
Traffic Volume*						
No. of compaction blows each end of specimen by freely held Marshall hammer	75	75	75	75	75	75
Stability (kg), minimum	1000	1100	1200	800	900	1000
Marshall Flow (mm)	2 – 3.5	2 – 3.5	2 – 3.5	2 – 3.5	2 – 3.5	2 – 3.5
Stiffness (kg/mm), minimum	450	450	550	400	400	500
% Air Voids	3 – 5	4 – 6	4 – 6	4 – 6	4 – 7	4 – 7
% Voids in Mineral Aggregate (VMA)	Minimum 13 (19mm NMAS) Minimum 14 (12.5mm NMAS)			Minimum 12 (25 mm NMAS) Minimum 13 (19mm NMAS)		
% Voids Filled with Asphalt (VFA)	60 – 75	55 – 70	50 – 65	60 – 75	55 – 70	50 – 65
Loss of Marshall Stability by submerging specimens in water at 60°C for 24 hours as compared to stability measured after submersion in water at 60°C for 30 minutes (max. % loss), ASTM D1075	25	25	25	30	30	30
% Air Voids at Refusal, minimum	2	2	2	2	2	2
Filler to bitumen ratio	0.8 – 1.4					

C. Superpave Volumetric Mix Design Method

C.1 The Superpave volumetric mix design method shall conform to the requirements of the Superpave Volumetric Design Method (Asphalt Institute Manual Series SP-2 or AASHTO MP 2).

C.2 The bitumen mix shall conform to the mix design requirements shown below:

Design	Gyratory compaction level and % theoretical maximum specific gravity, Gmm			Minimum voids in the mineral aggregate (VMA %)			Voids	Dust to Binder Ratio
ESALs				Nominal Maximum Aggregate Size				
Million	N _{initial}	N _{design}	N _{max}	25.0	19.0	12.5		
<0.3	6 ≤ 91.5%	50 ≤ 96.0%	75 ≤ 98.0%	12.0	13.0	14.0	70-80	0.8 – 1.6
0.3 to <3	7 ≤ 90.5%	75 ≤ 96.0%	115 ≤ 98.0%				65-78	
3 to <10	8 ≤ 89.0%	100 ≤ 96.0%	160 ≤ 98.0%				65-75	
10 to <30	8 ≤ 89.0%	100 ≤ 96.0%	160 ≤ 98.0%				65-75	
>30	9 < 89.0%	125 < 96.0%	205 < 98.0%				65-75	

C.3 The consensus aggregate properties are based on the traffic level and the position within the pavement structure. The coarse and fine aggregate properties shall comply with AASTHO M323 requirements:

Design ESALs (Million)	Fractured Face Coarse Aggregate (1 face % min/ 2 face % min)		Uncompacted Void Content of Fine Aggregate (% min)		Sand Equivalent (% min)	Flat & Elongated (% max)
	Depth from Surface (mm)		Depth from Surface (mm)			
	≤ 100	> 100	≤ 100	> 100		
<0.3	55/--	--/--	-	-	40	-
0.3 to <3	75/--	50/--	40	40	40	10
3 to <10	85/80	60/--	45	40	45	10
10 to <30	95/90	80/75	45	40	45	10
>30	100/100	100/100	45	45	50	10

C.4 The aggregate gradation shall satisfy the Superpave control points as given in AASHTO MP-2:

SIEVE SIZE (MM)	12.5mm NMAS		19.0mm NMAS		25.0mm NMAS	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
37.5	-	-	-	-	-	100
25.0	-	-	-	100	90	100
19.0		100	90	100	-	90
12.5	90	100	-	90	-	-
9.5	-	90	-	-	-	-
4.75	-	-	-	-	-	-
2.36	28	58	23	49	19	45
1.18	-	-	-	-	-	-
0.600	-	-	-	-	-	-
0.300	-	-	-	-	-	
0.150	-	-	-	-	-	-
0.075	2	10	2	8	1	7

6.03.04 JOB MIXES AND PROJECT MIXES

A. The Contractor shall submit for the Engineer's approval the proposed Job Mix Formula at least 30 days prior to the date of mix production at the mixing plant and after receiving approval of the aggregates and delivery to the Site of the bitumen specified.

B. The Job Mix Formula shall stipulate a single combined grading of all aggregate and filler materials showing the specific ranges in percentage 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 or Superpave method of mix design and relevant procedures. 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 or Superpave 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°C.

E. For Marshall Mixes, 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. For Superpave mixes, volumetrics shall be calculated in accordance with the procedure give in the Asphalt Institute Manual, SP-2 or AASHTO MP-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. Superpave gyratory compactor shall be used to compact Superpave specimens based on the compaction levels specified in Section 6.03.03(C).

G. In order to meet the moisture susceptibility requirements, an approved additive such as 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 1-2% 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 the mixing plant to supply the individual aggregates, mineral filler and bitumen in the correct proportion to produce a final project mix conforming to the job mix limits given in Table 6.3.1.

TABLE 6.3.1: MAXIMUM VARIATIONS OF PROJECT MIX FROM APPROVED JOB MIX

Aggregates passing No. 4 (4.75mm) and larger	± 4%
Aggregates passing No. 8 (2.36 mm)	± 3%
Aggregates passing No. 16 (1.18 mm)	± 3%
Aggregates passing No. 30 (0.6 mm)	± 3%
Aggregates passing No. 50 (0.3 mm)	± 3%
Aggregates passing No. 100 (0.15mm)	± 1%
Aggregates passing No. 200 (0.075mm)	± 1%
Bitumen content	± 0.2%
Temperature of mixing and placement	± 10°C
Air void content	± 1%

I. Any deviation from the limits in Table 6.3.1 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 re-approved 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.

6.03.05 EQUIPMENT

A. General

Plant and equipment for mixing, transporting, spreading and compacting bituminous mixes shall conform with the requirements of the Engineer 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, MS-22, SP-1, and SP-2 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, eveners 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 leveling 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.

6.03.06 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.

6.03.07 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 °C. If any aggregates contain excess moisture that may cause foaming in the mixture or their temperature is in excess of 170 °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°C of the aggregate temperature. Unless otherwise directed, the bitumen temperature shall be as given in Table 6.3.2.

TABLE 6.3.2: BITUMEN PROPERTIES

<u>Penetration Grade of Bitumen</u>	<u>PG Grade of Bitumen</u>	<u>Viscosity (Centistokes)</u>	<u>Max. Temperature °C Immediately after discharge from Pugmill</u>
85 - 100 pen.	PG 58-xx	170 ± 20	160
60 - 70 pen.	PG 64-xx	170 ± 20	165
40 - 50 pen.	PG 70-xx	170 ± 20	170
-	PG 76-xx	170 ± 20	175

E. Any mix subjected to higher temperatures than those shown in Table 6.3.2 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:

$$\text{Mixing time (sec)} = \text{Pugmill dead capacity (kg)} \text{ divided by } \text{pugmill output (kg/sec)}$$

6.03.08 SURFACE PREPARATION

A. When the bituminous mix is to be placed on a prepared subgrade, sub-base 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 6.02 - 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 6.02 - 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.

6.03.09 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°C below the discharge temperature at the mixing plant. The minimum temperature for the commencement of compaction is 130°C. Mix loads with temperatures less than 130°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°C or above and the surface temperature of the underlying course is at least that specified in Table 6.3.3, 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 6.3.3: MINIMUM SURFACE TEMPERATURES FOR ASPHALT CONSTRUCTION

<u>Asphalt Course Thickness</u>	<u>Minimum Surface Temperature °C</u>
100 mm or greater	5
Greater than 50mm but less than 100mm	8
50mm 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 6.02 - 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 be 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 tyre 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/m².

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 6.3.4.

TABLE 6.3.4 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 °C.

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 97.5% of the average bulk specific gravity determined in the lab 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.

6.03.10 SAMPLING AND TESTING

A. Sampling and testing shall conform to the relevant requirements of these Specifications - Samples and Approvals, and Table 6.3.5.

TABLE 6.3.5: 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	<u>Core Samples</u> 7- Density and thickness 8- Bitumen penetration grade verification	Every 200m per lane and each layer and When requested by the Engineer

B. The bulk specific gravity shall be determined in accordance with AASHTO T 166. The 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. Core samples for in-situ bulk specific gravity determination and verification of bitumen binder penetration grade 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.

6.03.11 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.

6.03.12 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.

6.03.13 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 6.02 - 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 6.04 BITUMINOUS BASE COURSE

6.04.01 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, sub-base or subgrade as and where shown on the Drawings.

6.04.02 MATERIALS

- A.** All materials shall conform to the relevant requirements of Section 6.01 - Materials for Bituminous Construction.
- B.** Unless otherwise shown on the Drawings, bitumen for base course construction shall be 60/70 penetration graded bitumen or PG 64-10.
- 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.

6.04.03 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 6.03 - Bituminous Courses.
- B.** After the Job Mix Formula has been established and approved by the Engineer, all mixes furnished shall conform to it within the stated tolerances (Section 6.03.04).
- C.** The Job Mix Formula shall be re-established if the source of aggregate, filler or bitumen changes.

6.04.04 EQUIPMENT

Plant and equipment for mixing, hauling, placing and compacting bituminous base course material shall conform to the relevant requirements of Section 6.03 - Bituminous Courses.

6.04.05 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 6.03 - Bituminous Courses.

6.04.06 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 6.03 - Bituminous Courses.

6.04.07 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 6.03 - Bituminous Courses.

6.04.08 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 6.03 - 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 97.5% of the average bulk density for each day's production.

6.04.09 SAMPLING AND TESTING

Sampling and testing shall conform to the relevant requirements of Section 6.03 - Bituminous Courses.

6.04.10 SURFACE TOLERANCES

A. Surface tolerances shall conform with the relevant requirements of Section 6.03 - 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.

6.04.11 DETERMINATION OF THICKNESS

A. Procedures for determining the average compacted thickness of bituminous base course shall conform with the relevant requirements of Section 6.03 - 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.

6.04.12 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 6.03 - 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 6.02 - Bituminous Prime and Tack Coats.

PAY ITEM	UNIT OF MEASUREMENT
(6.04.1) Bituminous Base Course	Cubic Metre (m ³)
(6.04.2) Bituminous Base Course in Temporary Diversions	Cubic Metre (m ³)

SECTION 6.05 BITUMINOUS WEARING COURSE

6.05.01 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.

6.05.02 MATERIALS

A. All materials shall conform to the relevant requirements of Section 6.01 - Materials for Bituminous Construction.

B. Unless otherwise shown on the Drawings, the bitumen grade for wearing course construction shall be in accordance with the penetration or PG grading map of Lebanon in Section 6.03.03.

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.

6.05.03 JOB MIX AND PROJECT MIX

Wearing course job mixes shall be formulated in accordance with the relevant requirements of Section 6.03 - Bituminous Courses and the following:

A. Air Voids Analysis

A.1 The design range of air voids (Section 6.03.03) shall be the level desired after several years of traffic.

A.2 The laboratory compactive effort shall be selected for the expected traffic demand.

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 Section 6.03.03.

B. Mix Design

B.1 The bituminous mixture shall be designed with the procedures and requirements of Section 6.03 - Bituminous Courses.

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 Bitumen content shall be calculated by weight of total mixture.

B.5 The compacted thickness of any layer shall be at least twice the nominal maximum aggregate size for wearing course unless otherwise directed by the Engineer.

B.8 The gradations in Section 6.03.03 represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The selection of any of the gradations 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 is 25mm unless otherwise directed by the Engineer.

B.9 The aggregate shall have a gradation within the limits designated in Section 6.03.03 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 specified in Section 6.03.04 and shall be applied to the Job Mix Formula to establish a job control grading band.

B.11 The aggregate gradation may be adjusted within the limits designated in Section 6.03.03 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.

6.05.04 EQUIPMENT

Plant and equipment for mixing, hauling, placing and compacting bituminous wearing course materials shall conform to the relevant requirements of Section 6.03 - Bituminous Courses.

6.05.05 CONSTRUCTION OF TRIAL SECTIONS

Trial sections shall be constructed as and where directed and in accordance with the relevant requirements of Section 6.03 - Bituminous Courses.

6.05.06 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 6.03 - Bituminous Courses.

6.05.07 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 6.03 - Bituminous Courses.

6.05.08 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 6.03 - 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/m² 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/m².

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 97.5% of the average Bulk Density for each day's production.

6.05.09 SAMPLING AND TESTING

Sampling and testing shall conform to the relevant requirements of Section 6.03 - Bituminous Courses.

6.05.10 SURFACE TOLERANCES

A. Surface tolerances shall conform with the relevant requirements of Section 6.03 - 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 $\pm 6\text{mm}$.

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.

6.05.11 DETERMINATION OF THICKNESS

A. Procedures for determining the average compacted thickness of bituminous wearing course shall conform with the relevant requirements of Section 6.03 - 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.

6.05.12 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 6.03 - 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 6.02 - Bituminous Prime and Tack Coats.

PAY ITEM

**UNIT OF
MEASUREMENT**

6.05.1	Bituminous Wearing Course	Cubic Metre (m ³)
6.05.2	Bituminous Wearing Course including Basalt Aggregate	Cubic Metre (m ³)
6.05.3	Bituminous Wearing Course in Temporary Diversions	Cubic Metre (m ³)

SECTION 6.06: BITUMINOUS SEAL COATS AND SURFACE DRESSINGS

6.06.01 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.

6.06.02 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 6.01 - 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 6.01 - 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 6.01 - Materials for Bituminous Construction.

6.06.03 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 these Specifications - Contractor's Plant and Equipment.

6.06.04 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.

6.06.05 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 6.6.1.

Table 6.6.1: TYPICAL SEAL COAT APPLICATION RATES

Types of Seal Coat	Rate of Application	
	Aggregate (Kg/m²)	Binder (Kg/m²)
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.

6.06.06 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 °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.

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 6.02 - 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/ m²

C. Heating of Bitumen

The temperature of cutback bitumen and of emulsified bitumen at the time of application shall be as specified in Section 6.01 - 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 sealed 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 SBSB and DBSB 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.

6.06.07 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/m² 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.

6.06.08 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.

PAY ITEM	UNIT OF MEASUREMENT
6.06.1 Single Bituminous Surface Dressing	Square metre (m ²)
6.06.2 Double Bituminous Surface Dressing	Square metre (m ²)
6.06.3 Bituminous Slurry Seal Coat	Square metre (m ²)

SECTION 6.07 BITUMINOUS LEVELING COURSE

6.07.01 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.

6.07.02 MATERIALS

- A.** All materials shall conform to the relevant requirements of Section 6.01 - Materials for Bituminous Construction.
- B.** Unless otherwise shown on the Drawings, materials shall also conform to the requirements of Section 6.05 - Bituminous Wearing Course.

6.07.03 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 6.03 - Bituminous Courses and Section 6.05 - Bituminous Wearing Course.
- B.** The Job Mix for bituminous leveling courses shall conform to the requirements of Section 6.05 - Bituminous Wearing Course.

6.07.04 EQUIPMENT

Plant and equipment for mixing, hauling, placing and compacting bituminous leveling course materials shall conform to the relevant requirements of Section 6.03 - Bituminous Courses.

6.07.05 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 6.03 - Bituminous Courses.

6.07.06 SURFACE PREPARATION

A. Damaged pavement surfaces shall be repaired by patching prior to receiving the bituminous leveling course in accordance with the relevant requirements of Section 6.08: 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 leveling 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 leveling courses required to obtain the desired surface.

C. Prior to placing leveling courses the existing pavement surface shall be prepared in accordance with the relevant requirements of Section 6.03 - Bituminous Courses, including the use of prime and tack coats as appropriate.

6.07.07 DELIVERY, SPREADING AND FINISHING

A. The delivery, spreading and finishing of leveling courses, including compaction, shall conform to the relevant requirements of Section 6.05 - Bituminous Wearing Course.

B. In areas where a specific grade and superelevation are to be achieved by the leveling courses, setting out and level control shall be based on a reference line installed in accordance with the relevant requirements of Section 6.03 - Bituminous Courses. In areas of minor leveling such as filling of potholes or small isolated areas, a mobile reference line or alternative control system may be approved by the Engineer.

6.07.08 SAMPLING AND TESTING

A. Sampling and testing of leveling courses shall conform to the relevant requirements of Section 6.03 - 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.

6.07.09 SURFACE TOLERANCES

Surface Tolerances for leveling courses shall conform to the relevant requirements for Binder Courses in Section 6.04 - Bituminous Base Course.

6.07.10 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 6.03 - Bituminous Courses.

6.07.11 MEASUREMENT

A. Bituminous leveling 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 6.03 - "Bituminous Courses".

	PAY ITEM	UNIT OF MEASUREMENT
(6.07.1)	Bituminous Base Course for Leveling and Patching	Cubic Metre (m ³)
(6.07.2)	Bituminous Wearing Course for Leveling and Patching	Cubic Metre (m ³)

SECTION 6.08: PAVEMENT REPAIRS, TRENCH EXCAVATION AND REINSTATEMENT WORKS

6.08.01 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 or deposition of any building materials, debris, temporary foundation or the placing of any equipment.

6.08.02 MATERIALS

- A.** All pavement materials shall conform to the relevant requirements of Section V - Sub-Base and Base Courses and Section 6.01 –Materials for Bituminous Construction.

6.08.03 EQUIPMENT

All plant and equipment shall conform to the relevant requirements of these Specifications - Contractor's Plant and Equipment.

6.08.04 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

6.08.05 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.

6.08.06 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 V- Subbase & Base Courses 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 V - Sub – Base & 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 6.02 – 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 6.04 – Bituminous Base Course and Section 6.05 – 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.

6.08.07 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 I and current LIBNOR Standards.

6.08.08 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 I 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.

6.08.09 SAMPLING AND TESTING

Testing of repair materials shall conform to the relevant requirements of Section V - Subbase & Base Courses and Section 6.03 – Bituminous Courses. Sampling shall be as ordered by the Engineer.

6.08.10 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 6.04 – Bituminous Base Course and Section 6.05 – Bituminous Wearing Course.
- C** Any deficiency in the wearing course surface shall be corrected by cutting out and replacing.

6.08.11 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.

PAY ITEM	UNIT OF MEASUREMENT
(6.8.1) Existing Pavement Repairs up to (<i>state depth</i>) in depth.	Square metre (m ²)
(6.8.2) Trench Reinstatement up to (<i>state depth</i>) in depth	Square metre (m ²)

SECTION 6.09 ROAD PLANING AND GRINDING

6.09.01 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.

6.09.02 EQUIPMENT

- A.** All plant and equipment shall conform to the relevant requirements of the Specifications – 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.

6.09.03 ROAD PLANING AND 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 6.12, 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 1 metre 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 6.3.10 of Specification Section 6.03.

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 Section VII - 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.

6.09.04 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 Section 6.08: 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 6.02: 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 recompact 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 6.02: 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.

6.09.05 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 6.05: Bituminous Wearing Course or Section 6.04 Bituminous Base Course as appropriate.

C. Prime coat under the new bituminous layers shall also be paid separately as specified under Section 6.02: 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.

F. Asphalt leveling course to existing surfaces, including scarifying with minimum milling, cleaning and applying tack coat to the existing surface shall be paid separately.

PAY ITEM	<i>UNIT OF MEASUREMENT</i>
Planing (<i>to a specified depth</i>) Existing Asphalt Surface	Square Metre (m ²)
Grinding (<i>to a specified depth</i>) Existing Concrete Surface	Square Metre (m ²)
Scarifying with minimum milling	Cubic Metre (m ³)

SECTION 6.10 IN-SITU BITUMINOUS KERB

6.10.01 SCOPE

A. The work covered in this section consists of furnishing of materials and constructing in- situ bituminous kerb as and where shown on the Drawings.

6.10.02 MATERIALS

A. All materials shall conform to the relevant requirements of section 6.01: Materials for Bituminous Construction.

B. Unless otherwise shown on the Drawings, bitumen for in-situ bituminous kerb shall be 60/70 penetration grade bitumen.

C. Aggregate shall be hard, clean durable crushed slag or gravel complying with the requirements of BS 594-1:2005. Nominal size of aggregate shall be 10mm and shall not exceed 20mm.

D. The percentage of the binder by mass of the total shall be 6-9 per cent unless otherwise instructed by the Engineer,

6.10.03 CONSTRUCTION

A. General

A.1 In situ bituminous kerbs shall be laid by an approved machine to the dimensions shown on the Drawings. The kerbs shall be closely compacted with regular sides, edges, arrises and chamfers finished to a smooth surface, free from blowholes and indentations.

A.2 Making and placing of in situ bituminous kerbs shall comply with the recommendations of BS5931:1980.

B. Plant and Equipment

B.1 All plant and equipment shall conform to the relevant requirements of Division 1: General Requirements, Contractor's Plant and Equipment and to Section 6.03: Bituminous Courses.

B.2 The mix shall be laid by a self propelled automatic kerbing machine or a paver capable of producing a dense, smooth-surfaced kerb true to line and level.

- B.3** The automatic kerbing machine shall meet the following requirements;
- The weight of the machine shall provide the required compaction without riding above the kerb bedding material.
 - The machine shall form kerbing that is uniform in texture, shape and density.

B.4 The Engineer shall consider the construction of kerbing by other than the automatic kerber or machine when short sections or sections with short radii are required or for other warranted reasons. The resulting kerbing shall conform in all respects to the kerbing produced by machine.

C. Job Mix Formula

C.1 The Job Mix Formula shall be established by the Contractor in accordance with the procedures and requirements of Section 6.03: Bituminous Courses.

C.2 Where the kerb is immediately close to the carriageway and where there is a high risk from mechanical damage from vehicle impact, a harder grade of binder with a courser aggregate content, to the approval of the Engineer, shall be used.

D. Trial Mixes

The Contractor shall make trial mixes and carry out tests using the same plant to be used in the works as and where directed by the Engineer and in accordance with the relevant requirements of Section 6.03: Bituminous Courses.

E. Surface Preparation

E.1 The surface on which kerbing is to be laid shall be dry and cleaned of loose and deleterious material.

E.2 A tack coat, complying with the requirements of Section 6.02: Bituminous Prime and Tack Coats shall be applied to the surface before the kerb is laid. The Contractor shall prevent the spread of tack coat to areas outside of the kerb area.

E.3 Preparation of the surface upon which the bituminous kerb is to be laid and the use of tack coat shall conform to the relevant requirements of Section 6.03: Bituminous Courses.

6.10.04 MEASUREMENT

A. In-situ Bituminous Kerb shall be measured by the linear metre furnished, installed, completed and accepted.

B. Surface preparation and tack coat shall not be measured or paid for separately but shall be deemed to be included in the rate for In-Situ Bituminous Kerb.

PAY ITEM	UNIT OF MEASUREMENT
6.10.1 In Situ Bituminous Kerb (<i>state dimension</i>)	Linear metre (m)

SECTION 6.11 RECYCLING OF PAVEMENT MATERIALS

6.11.01 SCOPE

The work covered in this Section consists of the re-use, after processing, of existing bituminous and granular base courses in the new road pavement where and as shown on the Drawings or as directed by the Engineer. The categories of recycling covered consist of Hot Mix, Cold Mix and Surface Recycling.

B. Hot Mix Recycling is the method whereby a portion of the existing pavement structure, including in some cases the underlying untreated base material is removed, sized and mixed hot with added asphalt at a central plant. The process includes the addition of new aggregate and a softening agent. The finished product is a hot mix asphalt base or wearing course.

C. Cold Mix Recycling is the method whereby the pavement structure, including in some cases the underlying untreated base material, is either processed in place or removed and processed at a central plant. The materials are mixed cold and are reused as an aggregate base or, if fresh asphalt is added, as an asphalt base course.

D. Surface Recycling is the method whereby the surface of an existing asphalt pavement is planed, milled or heated in place and scarified, remixed re-laid and rolled after the addition of fresh asphalt, softening agents, aggregates or a combination of these. .

6.11.02 MATERIALS

A. Asphalt Mix from Recycled Pavement Materials

A.1 The maximum percentage of recycled asphalt pavement material in the new asphalt mix shall be 50%.

A.2 The reclaimed pavement materials shall be processed where necessary and blended with reclaimed aggregate material and/or new aggregate to obtain a combined aggregate gradation in accordance with Section 6.01- Materials for Bituminous Construction Processing of reclaimed asphalt shall consist of crushing or screening. Any method proposed by the Contractor shall be in accordance with the Drawings or approved by the Engineer.

A.3 Mix designs for the new asphalt pavement shall be carried out in accordance with the procedure described in MS2 Mix Design Methods for Asphalt Concrete published by the Asphalt Institute, USA.

A.4 All new pavement materials shall conform to the relevant requirements of Section 6.01 - Materials for Bituminous Construction.

B. Base and Sub-base Materials from Recycled Pavement Materials

Aggregate base and sub-base material obtained from recycled pavement materials shall conform to the requirements of Section V - Aggregate Base and Sub-base Courses. Site arising materials shall be crushed, screened or blended as necessary to meet the relevant specification requirements and in accordance with the method shown on the Drawings or approved by the Engineer.

6.11.03 EQUIPMENT

A. All plant and equipment shall conform to the relevant requirements of these Specifications - Contractor's Plant and Equipment, and the following

B. The plant used for hot and cold mix recycling shall be capable of removal of the pavement course(s) detailed on the Drawings or instructed by the Engineer without disturbance to or contamination of the underlying pavement layer. If specific methods of removal of the existing pavement materials are shown on the Drawings or instructed by the Engineer, then the plant shall be capable of compliance with these requirements.

C. The plant used for surface recycling shall consist of either a paving train or a preheater and remixer combination. Both methods shall have the facility to mix recycled and fresh pavement materials in the correct proportions.

6.11.04 ROAD RECYCLING OPERATIONS

A. Except on structures, the entire area of pavement in locations designated on the Drawings or as directed by the Engineer shall be recycled to the depth as detailed.

B. The Contractor shall submit a method statement for prior approval by the Engineer of his proposal for recycling all pavement layers as detailed on the Drawings, instructed by the Engineer or proposed by the Contractor. Method statements shall include the locations and types of materials to be recycled, the plant to be used, and outline programme of works and material sample test results demonstrating compliance with the Specifications.

C. Recycled asphalt shall be laid and compacted in accordance with the relevant requirements of Section 6.03: Bituminous Courses.

D. Recycled aggregate base and sub-base courses shall be laid and compacted in accordance with the relevant requirements of Section V: Sub-Base and Aggregate Base Courses.

E. A 100m trial section shall be identified the Engineer to confirm the effectiveness of the Contractor's plant to conform to the above requirements and to provide where necessary material for mix designs in accordance with the appropriate specification clauses. The trial section shall be completed and the excavation method and mix designs approved by the Engineer in advance of the recycling work.

F. Pavement recycling operations on trafficked roads shall be constructed in sections so that work shall not be left uncovered overnight. If this is unavoidable due to plant breakdown or other unforeseen circumstance, then the area left uncovered shall be fenced off, marked and signed for the protection of all road users in accordance with the Safety, Health and Environmental Regulations, all at the Contractor's expense.

6.11.05 MEASUREMENT

A. Recycling of the existing asphalt shall be measured by the square metre of recycled pavement area to the specified depth, including planing or excavation, processing, the addition of fresh material and laying and compaction of the recycled material. No additional payment shall be made for planing or excavation or for replacement pavement material to a greater depth or surface area than specified or instructed by the Engineer. All surface preparation and cleaning works specified above shall be deemed to be included in this pay item.

B. The Contract price paid per square metre for recycling existing pavement shall include full compensation for furnishing all labour, materials, tools, equipment and incidentals and for all work involved in planing or excavation of the existing pavement, processing, supply of fresh material, laying and compaction of the reformed material, removing and disposing of excess residue, all as shown on the Drawings, as specified in these specifications and as directed by the Engineer.

PAY ITEM	UNIT OF MEASUREMENT
(4.11.1) Recycling (<i>to a specified depth</i>) Existing Road Surface to form (<i>specify pavement layer and depth</i>)	Square Metre (m ²)

SECTION 6.12 PROVISIONAL SPECIFICATIONS FOR HIGH VOLUME ROADS (NEW)

6.12.01 BAILEY METHOD FOR AGGREGATE GRADATION SELECTION

A. The aggregate material for the bituminous surface and base course layers shall satisfy the below Bailey conformity requirements:

CONFORMITY EQUATIONS	BITUMINOUS SURFACE COURSE (12.5mm NMAS)	
	Minimum	Maximum
$\frac{\%Passing\ 6.25mm - \%Passing\ 2.36mm}{100 - \%Passing\ 6.25mm}$	0.5	0.65
$\frac{\%Passing\ 0.6mm}{\%Passing\ 2.36mm}$	0.35	0.5
$\frac{\%Passing\ 0.15mm}{\%Passing\ 0.6mm}$	0.35	0.5

CONFORMITY EQUATIONS	BITUMINOUS SURFACE/BASE COURSE (19mm NMAS)	
	Minimum	Maximum
$\frac{\%Passing\ 9.5mm - \%Passing\ 4.75mm}{100 - \%Passing\ 9.5mm}$	0.6	0.75)
$\frac{\%Passing\ 1.18mm}{\%Passing\ 4.75mm}$	0.35	0.5
$\frac{\%Passing\ 0.30mm}{\%Passing\ 1.18mm}$	0.35	0.5

CONFORMITY EQUATIONS	BITUMINOUS BASE COURSE (25mm NMAS)	
	Minimum	Maximum
$\frac{\%Passing\ 12.5mm - \%Passing\ 4.75mm}{100 - \%Passing\ 12.5mm}$	0.7	0.85
$\frac{\%Passing\ 1.18mm}{\%Passing\ 4.75mm}$	0.35	0.5
$\frac{\%Passing\ 0.30mm}{\%Passing\ 1.18mm}$	0.35	0.5

6.12.02 PERFORMANCE TESTING

A. Simple Performance Testing (SPT)

A.1 Simple Performance Test shall be carried out at the mix design stage on the various selected asphalt marshal mixes of the surface course and base course layers.

A.2 The test shall be conducted in accordance with AASHTO TP-62 “Determining Dynamic Modulus of Hot Mix Asphalt (HMA)”. Dynamic modulus, $|E^*|$, and phase angle, ϕ , values are to be determined over a range of temperatures and frequencies.

A.3 The AMPT (Simple Performance Tester) or the universal Triaxial testing machine can be used for conducting the test. The standard error in applied stress and measured strain shall not exceed 10%.

A.4 From each asphalt concrete mix, three replicate samples shall be tested to determine the resulting $|E^*|$ mastercurves. Overall variability in $|E^*|$ among the three replicates, using three LVDTs per replicate, shall not exceed $\pm 12\%$. The air void content of the specimens used for testing shall be within $4 \pm 0.5\%$.

A.5 The average $|E^*|$ master curve shall be provided by the Contractor for further evaluation by the Engineer based on the prevailing conditions of the pavement structures under study. The Engineer will assess the obtained results and suggest any necessary modifications to the asphalt concrete mixes, whenever applicable.

A.6 The final results will be used as a benchmark for quality control purposes of the asphalt concrete layers during construction. Three asphalt concrete specimens shall be tested for dynamic modulus for every 3,500 Tons of mix. The average mastercurve will be compared to the established benchmark mastercurve of the approved mix. The same procedure and tolerances stated above shall apply.

B. Hamburg Wheel Track Testing (HWTT)

B.1 The rutting potential and moisture-susceptibility of asphalt mixtures shall be determined on the various selected asphalt Marshall mixes of the surface course and base course layers, in accordance with the Accelerated Hamburg Wheel Tracking test according to AASHTO T324 standard at 60°C. The test shall be conducted at the mix design stage and its results shall be used as a benchmark for quality control purposes at the construction stage.

B.2 Three tests shall be conducted for every 3,500 Tons of mixture placed. Each test shall be conducted on two laboratory compacted specimens. Calculation and reporting shall be done for each test. The average of the three tests shall also be reported. If the mixture fails to meet the Hamburg Wheel criteria, no further mixture will be accepted until the Contractor takes such action as is necessary to furnish a mixture meeting the criteria.

B.3 Hamburg Wheel Test criteria: The maximum allowable rut depth shall be 0.2 in (5 mm) at 10,000 passes and 0.5 in. (12.5 mm) at 20,000 passes.

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CONCRETE WORKS
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SECTION – VII

CONCRETE WORKS

700 – GENERAL

700.01 Description - This Section contains Specifications for concrete work which consists of preparing concrete mixes of the different classes, transporting and placing on prepared surfaces or in prepared forms, including supplying and fixing of formwork and temporary work; supplying, cutting, bending and placing of reinforcing steel, vibrating, tamping and curing, supplying and installing precast units, all in accordance with these Specifications and in conformity with the Drawings.

701 – MATERIALS AND TESTING

701.01 Standards and Code - Unless otherwise indicated on the Drawings, the following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

A 36	Specification for Structural Steel
A 82	Specification for Steel Wire, Plain for Concrete Reinforcement
A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement [Metric]
C 33	Specification for Concrete Aggregates.
C 39	Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 40	Test Method for Organic Impurities in Fine Aggregates for Concrete
C 87	Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
C 88	Test Method for Soundness of Aggregates by use of Sodium or Magnesium Sulphate
C 94	Specification for Ready Mixed Concrete.
C 117	Test Method for Materials Finer than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing
C 123	Test Method for Lightweight Pieces in Aggregate
C 136	Method for Sieve Analysis of Fine and Coarse Aggregates
C 140	Concrete Masonry Units - Sampling and Testing
C 143	Slump of Hydraulic Cement Concrete
C 150	Specification for Portland Cement
C 227	Potential Alkali Reactivity for Cement Aggregate Combinations, (Mortar Bar Method)
C 289	Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)
C 295	Guide for Petrographic Examination of Aggregates for Concrete
C 309	Liquid Membrane - Forming Compounds for Curing Concrete
C 342	Test Method for Potential Volume Change of Cement Aggregate Combination

C 494	Chemical Admixtures for Concrete
C 586	Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)
D 1751	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction
D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
D 3405	Joint Sealants, Hot-Poured for Concrete and Asphalt Pavements
D 3406	Joint Sealants, Hot-poured, Elastomeric-Type, for Portland Cement Concrete Pavements
E 8	Tension Testing of Metallic Materials

AASHTO

M 6	Fine Aggregate for Portland Cement Concrete
M 31	Deformed and Plain Billet Steel Bars for Concrete Reinforcement
M 92	Wire Cloth for Testing Purposes
M 148	Liquid Membrane - Forming Compounds for Curing Concrete
M 153	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
M 157	Ready Mixed Concrete
M 213	Performed Expansion Joint Fillers for Concrete Paving and Structural Construction
T 2	Sampling Aggregates
T 68	Tension Testing of Metallic Materials
T 96	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
T 119	Slump of Portland Cement Concrete
T 176	Plastic Fines in Graded Aggregates & Soils by Use of the Sand Equivalent Test

BS

BS 12	Portland Cement
BS 410	Test Sieves
BS 812	Methods for Sampling and Testing of Mineral Aggregates, Sands and Fillers
BS 882	Aggregate from Natural Sources for Concrete (Including Granolithic).Coarse and Fine Aggregates from Natural Sources
BS 1199	Building Sands From Natural Sources
BS 1881	Methods of Testing Concrete
BS 2499	Hot Applied Joint Sealants for Concrete Pavements
BS 3148	Methods of Tests for Water For Making Concrete
BS 4466	Bending Dimensions and Scheduling of Reinforcement for Concrete
BS 4483	Steel Fabric for Reinforcement of Concrete
BS 5135	Metal-Arc Welding of Carbon and Carbon Manganese Steels
BS 5212	Cold Poured Joint Sealants for Concrete Pavements
BS 7263	Precast Concrete Flags, Kerbs, Channels, Edgings and Quadrants
BS 8007	Code of Practice for Design of Concrete Structures for Retaining Aqueous Liquids

ACI

ACI-315	Manual of Standard Practice for Detailing Reinforced Concrete Structure
ACI-347	Formwork Design
ACI-350	Concrete Sanitary Engineering Structures and Revisions

FRENCH STANDARDS

AFNOR	Association Française pour la Normalisation
D.T.U.	Documents Techniques Unifiés
C.P.S.	Cahiers des Prescriptions Communes du Ministère Français de L'Equipment et du Logement

Fascicule 4, Titre I: Fourniture d'Acier et Autres Métaux. Armatures pour Béton Armé

Titre II: Armatures à Haute Résistance pour Constructions en Béton Précontraint par pré ou post Tension

Titre III: Aciers Laminés pour Constructions Métalliques

Titre IV: Rivets en Acier, Boulonneries à Serrage Contrôlé Destinés à L'Exécution des Constructions Métalliques

Fascicule 56: Protection des Ouvrages Métalliques contre la Corrosion

Fascicule 65 A: Exécution des Ouvrages de Génie Civil en Béton Armé ou Précontraint

Fascicule 66 (N): Exécution des Ouvrages de Génie Civil à ossature en Acier.

701.02 Samples and Tests - The Contractor shall furnish samples and test results for source approval by the Engineer of materials and products intended for use in concrete works. All sampling and testing of materials, products, workmanship and the completed work, required to check conformity of the work to the specified requirements shall be carried out by the Contractor.

701.03 Fine Aggregate - Fine aggregate for Portland cement concrete shall consist of natural sand in accordance with ASTM C33.

Water soluble chlorides in the fine aggregate shall not exceed 250 parts per million and water soluble sulphates shall not exceed 1300 parts per million as determined by the standard MPW test for water soluble chlorides and sulphates present in graded aggregates.

When aggregate is subjected to five cycles of the sodium sulphate soundness test (ASTM C88), the loss shall not exceed 10% by weight.

The gradation of fine aggregate used in portland cement concrete shall be in accordance with Table below:

Sieve Designation Standard	Alternate	Percent Passing
Mm		(by weight)
9.5	3/8	100
4.75	No. 4	90 - 100
2.36	No. 8	80 - 100
1.18	No. 16	60 - 90
0.600	No. 30	35 - 70
0.300	No. 50	5 - 30
0.150	No. 100	0 - 10

The percent passing the 0.075 mm (No. 200) Sieve shall not exceed 3%. The sand equivalent as determined by AASHTO T176 shall not be less than 70%.

The fine aggregate shall be of such uniformity that the fineness modules as defined in ASTM C33 shall not vary more than 0.20 either way from the fineness modulus of the representative samples used in the mix design.

The amount of deleterious substances shall not exceed the following limits when tested in accordance with ASTM C33:

<u>Substance</u>	<u>Percent by Weight</u>
Soft and Friable Particles	1.0
Coal and Lignite	0.5
Material finer than a No. 200 Sieve	3.0

Mortar Specimens made with the proposed fine aggregate, when tested in accordance with ASTM C87, shall have an average compressive strength of at least 90% of the strength of similar specimens made with the same cement and Ottawa sand.

The total acid soluble sulphate content (BS 812: Part 118 1988) of fine aggregate, expressed as sulphur trioxide (SO₃), shall not exceed 0.40% by dry weight. 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:

- The total sulphate content (SO₃) 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 (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.

701.04 Coarse Aggregate

Aggregates shall meet the requirements of ASTM C33.

Gradation of coarse aggregate shall be as indicated in the Table below

Plain Concrete B10 and B15		Prestressed Concrete and Reinforced Concrete B20, B25, B28, B33 and B40	
Sieve Size	Percent Passing (By Weight)	Sieve Size	Percent Passing (By Weight)
1-1/2 inch	100	1 inch	100
1 inch	90 - 100	3/4 inch	90 - 100
1/2 inch	25 - 60	1/2 inch	30 - 70
No. 4	0 - 10	No.4	0 - 10

The amount of deleterious substances shall not exceed the following limits:

Soft and friable particles maximum 3% by weight.

Materials finer than a 0.075 mm (No.200 Sieve) (ASTM C117) 1%

Flakiness (individual stockpiles) BS 812 (1975) 25%

Elongation index of coarse aggregate, BS 812, 15%

The percentage of wear of the aggregate shall not be greater than 50 as determined by AASHTO T96.

When the coarse aggregate is subjected to five cycles of the sodium sulphate soundness test (ASTM C88), the loss shall not exceed 12 per cent by weight.

The total acid soluble sulphate content (BS 812: Part 118 1988) of coarse aggregate, expressed as sulphur trioxide (SO₃), shall not exceed 0.40% by dry weight. The total acid soluble sodium chloride content, expressed as sodium chloride (NaCl), shall not exceed 0.05% by dry weight of coarse aggregate. The following overriding requirements shall apply:

- The total sulphate content (SO₃) 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 (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.

701.05 Water for Concrete Mixes and Curing - Unless otherwise authorised in writing by the Engineer, only potable water may be used for mixing concrete and other products containing cement. Similarly, only potable water may be used for curing concrete

and cement products. The water used must at all times comply with the requirements of BS 3148.

The water shall enter the mixers at as low a temperature as possible. Every effort should be made to protect water pipes and tanks from the sun, e.g. by burying, shading, insulating or painting white.

The PH of water used in concrete works shall be not less than 6.0 nor more than 8.0.

701.06 Cement

701.06.1 Unless otherwise specified on the Drawings or in the Contract Documents all cement shall be Portland Cement complying with the BS 12 or AASHTO M85 Type I in case of Ordinary Portland Cement.

One brand of cement as approved by the Engineer shall be used for all concrete works throughout the Project unless otherwise authorised by the Engineer in writing, except that, where a cement of a type other than Type I has been specified for part of the Works, a different brand of cement may be approved for each type of cement specified.

The acid-soluble alkali content of the cement, expressed as equivalent sodium oxide and calculated as $\text{Na}_2\text{O} + 0.658\text{K}_2\text{O}$, shall be less than 0.6% by weight.

The source of supply of cement shall be subject to the Engineer's approval and the Contractor shall at all times furnish the Manufacturer's test certificates and proof that the required Specification has been complied with, together with a note of the date of manufacture, certified by an independent agency in the country of origin. The Engineer shall have the power to reject a part or the whole of any consignment of cement if he considers it to be unsuitable for use in the works.

701.06.2 Cement shall be delivered to the site in bulk, or with the Engineer's approval cement may be supplied in sealed bags which shall bear the manufacturer's name and the date of manufacture. Bulk cement shall be stored in perfectly dry waterproof bins or hoppers; bagged cement shall be stored in perfectly dry waterproof sheds or other such temporary buildings approved by the Engineer. Such sheds or buildings shall be used exclusively for the storage of cement and shall be erected with the floors raised well above the ground.

A free passage of at least one meter shall be left between the cement and the side walls of the sheds. Access way shall also be left between the stored bag of cement such that every bag is visible. Each consignment of cement shall be stored apart from earlier consignments and consignments shall be used in the order in which they are delivered.

The Contractor shall provide weighing machines which shall be kept permanently in each shed or building for checking the weight of the bags of cement.

The Engineer shall have access at all times to the cement storage bins, hoppers, sheds or buildings.

Any consignment of cement which has become caked or otherwise adversely affected shall be removed from the site immediately at the Contractor's own expense. Any cement in storage for more than 6 months shall not be used. Regular tests shall be carried out on cement in storage and prior to use in the works.

During transport and storage the cement shall be fully protected from all weather elements. The temperature of the cement entering the mixers shall not exceed 45°C.

701.07 Reinforcing Steel - Reinforcing steel bars shall unless otherwise indicated comply with the requirements of French standard C.P.S. Fascicule 4 Titre I and II or other equivalent standard. Reinforcing bars shall be designation FeE24 or FeE40 HA as shown on the Drawings or instructed by the Engineer. Testing shall be in accordance with the applicable standards. Each reinforcing steel consignments shall be accompanied by a fully detailed and certified manufacturers certificate. All reinforcing bars shall be suitably bagged indicating the manufacturers name and reference numbers.

The Contractor shall, as required by the Engineer, carry out sampling and testing of reinforcing bars to check conformity with the specified requirements before use in the works.

702 – CLASSES OF CONCRETE

702.01 Mixes - Concrete to be used shall have the following mix designations and strength requirements.

Requirement	Class of Concrete						
	B10	B15	B20	B25	B28	B33	B40
Minimum Crushing Strength of test cylinders, MPA							
- at 7 days works cylinders	7	11	15	18	21	25	30
- at 28 days works cylinders	10	15	20	25	28	33	40
Maximum Water/Cement Ratio	0.70	0.60	0.55	0.50	0.45	0.45	0.42
Minimum Cement Content in kg/m ³	200	250	300	350	375	400	400

At the time of placing the concrete the slump shall not be less than 40 mm nor greater than 120 mm unless otherwise agreed with the Engineer.

ASTM C39 shall govern for the manufacture of comprehensive strength cylinders for all classes of Concrete.

Acceptance of the work will be based on 28 day cylinder strengths as determined under these Specifications.

702.02 Uses of Different Classes of Concrete - Unless otherwise specified in the Contract Documents the uses of different classes of concrete shall be as indicated on the Drawings or as instructed by the Engineer.

702.03 Admixtures - Chemical admixtures used for water reduction and retarding purposes shall be of a type approved by the Engineer and shall conform to the requirements of

Type A, Type D, Type F or Type G as specified in ASTM C494. The Contractor shall be entirely responsible for the use of any approved chemical admixtures and they shall be used in strict accordance with the Manufacturers' instructions. Unless otherwise recommended by the manufacturer the admixture shall be satisfactorily dispersed within the water required for the batch prior to its introduction into the mixer. Preliminary tests of strength and other tests including plant trials shall be carried out using the combination of aggregates, cements and admixtures proposed for use.

When changing the brand or type of cement further tests shall be carried out.

All admixture containers shall be clearly labelled showing the manufacturer's name, the date of manufacture, the expiry date and the type of admixture per ASTM C494.

702.04 Water-Cement Ratio - The quantity of water used in mixing shall be approved by the Engineer on the basis of preliminary tests and trial mixes and shall be the least amount that will produce a workable homogeneous plastic mixture which can be worked into the forms and around the reinforcement. In no circumstances shall the consistency of the concrete be such as to permit a separation of the aggregate from the mortar during handling. Excess water shall not be permitted and any batch containing such excess will be rejected.

In measuring water for each batch of concrete, allowance shall be made for the water contained in the aggregates and for the fluid content of any admixture. The total water in the batch shall be deemed to consist of the water carried by the aggregates and any admixtures plus the water added.

Frequent tests including the slump test shall be carried out to ensure that a consistent water content is maintained.

The concrete shall not bleed nor suffer plastic settlement.

In no case shall the water-cement ratio exceed that given in Table above for each particular class of concrete.

703 – MIX DESIGN

703.01 Mix Design - Samples of all materials to be used in the mix shall be submitted to the Engineer for testing and such samples shall be tested in as directed by the Engineer. No materials forming any part of this mix shall be delivered to the Site until the Contractor has received written approval to such material.

After receiving approval of the samples from the Engineer, the Contractor shall submit in writing to the Engineer a proposed mix design proportioned by weight and based on trial mixes conducted with the approved materials to be used for each specified class of concrete for the project. Each mix design submitted shall be accompanied by all relevant data including details of the proposed method of placement.

No concrete works will be allowed to commence before the Contractor receives approval in writing from the Engineer for his mix design

The Contractor must make arrangements for all the foregoing as early possible and no claims for delay or compensation will be considered on account of waiting for the Engineer's written approval.

Should a previously approved mix design become unsatisfactory for any reason, in the opinion of the Engineer, the Contractor shall submit a revised mix design for approval by the Engineer as previously described. All expenses incurred on account of the implementation of a new mix design, or delays incurred as a result of such changes being required, shall be entirely the responsibility of the Contractor and no claim for delay or compensation will be considered. During the currency of the Contract the Engineer will request samples and tests of the work mix at any time in order to check their conformity to the approved mix design.

All the foregoing shall be at the expense of the Contractor but shall in no way relieve him of any of his responsibilities under the Contract.

704 – METHOD OF CONSTRUCTION

704.01 Formwork and Falsework

704.01.1 Design - All formwork shall be designed and detailed by the Contractor who shall submit drawings to the Engineer early enough to permit review before erection of the forms.

If retarding admixtures are to be employed their effect should be duly considered during the calculation of the lateral pressures of the fresh concrete. Besides the weight of the formwork and freshly placed concrete the design loads shall include the weight of workmen, equipment, runways and impact, which together should be taken as not less than 250 kg/m² of horizontal projection. Braces and shoring for formwork shall be designed to resist all foreseeable lateral loads plus a lateral load equal to 3% of the total vertical load. Falsework shall be designed in accordance with the requirements of AASHTO, except that a horizontal force equivalent to 1% of the vertical loads shall be applied in addition to those specified by AASHTO.

When prefabricated formwork shoring or scaffolding units are used the manufacturer's recommendations for allowable loads may be followed if supported by test reports or successful experience records. For materials which will experience substantial re-use, reduced values may be required.

The design of the formwork shall be the sole responsibility of the Contractor and the strutting and bracing of the formwork shall be such that there shall be no harmful deformation of the forms under the weight of the plastic concrete or due to methods adopted for the placing and compacting thereof or due to any incidental loading. No appliance for supporting the formwork or stagings shall be built into the permanent structure except with the Engineer's approval.

Formwork shall be designed for vertical loads and lateral pressures in accordance with ACI 347. In addition, the formwork shall be constructed to provide completed concrete surface complying with the tolerances Specified therein.

The Contractor shall submit to the Engineer, for approval, shop drawings showing details of the falsework and forms intended to be used.

The shop drawings shall show the proposed details of construction such as sizes of members, spacing of bents, posts, studs, wales, stringers, collars, bolts, wedges, bracing, rate of pour and the manufacturer's recommended safe working capacity of all form ties and column clamps. All assumptions, dimensions, material properties and other data used in making the structural analysis shall be noted on the drawing. Upon request, the Contractor shall furnish copies of the design calculations to the Engineer for examination as a condition of approval.

704.01.2 Types - All formwork shall be fabricated in accordance with one or other of the types specified hereunder.

- a. Wrought Formwork** - The surface shall be tooled or wrought and the formwork shall be constructed of steel or plywood or planed and dressed timber or undressed timber lined with an approved fibreboard. Plywood shall have a thickness of not less than 12 mm and waterproof glue shall have been used in its fabrication. Where fair-faced concrete finish is required wrought formwork shall be used. All exposed concrete surfaces shall be fair-faced finish.
- b. Sawed Formwork** - Formwork shall be of timber as sawed at the mill, Boards shall be of the same width. Sawed formwork may be used where concrete surfaces are not required to have a fair-faced finish such as foundations below finished levels and non-visible surfaces of walls.
- c. Formwork for Special Finishes** - Where concrete visible surfaces are required to have special finishes as shown on the Drawings or as instructed by the Engineer, the formwork to be used shall be of an approved type suitable for producing the particular special finish.

704.01.3 Construction - The formwork shall be constructed accurately to represent the shape of the concrete as detailed on the Drawings. It shall be of suitable design and substantial construction and be approved by the Engineer. The Contractor shall make any necessary adjustment to allow for shrinkage settlement or deflection which may occur during construction so that the finished concrete sections conform accurately to the specified dimensions true to line level and camber.

Wooden boarded formwork shall be fixed with such openings between the individual boards that they will close completely after the wetting which will precede the concreting.

All timber used in the formwork shall be sound well-sealed and free from loose knots and all formwork shall be constructed so that the joints fit tight enough to prevent the leakage of grout. Wrought formwork shall have a completely smooth face with tight joints. In all formwork for visible surface the pattern of the shutter joints shall be to the approval of the Engineer.

Metal forms shall be used for all exposed surfaces of walls and columns and all such forms shall be to the approval of the Engineer. The forms should be of a type which does not require the use of wire or other ties that remain embedded in the concrete after the forms have been removed. Where ties are necessary bolts and rods should be used, but they must be arranged so that when the forms are removed no metal shall be within 30 mm of any surface.

Where holes are boxed out in the concrete for the subsequent installation of pipes, brackets, ragbolts or other ironwork or details the boxes shall become part of the formwork and shall be accurately set out and securely fixed. Should the Contractor elect to use other methods for building-in the above mentioned ironwork or details such methods shall be used only with the Engineer's prior approval but such approval shall in no way relieve the Contractor of his responsibility of the accuracy of the final finished positions of such ironwork and details to be built in.

Openings for the inspection of the inside of the formwork and for the escape of water used for washing out shall be formed so that they can be conveniently closed before placing of the concrete. Unless otherwise indicated, visible concrete corners shall in all cases be formed with 25 mm chamfers and splays. The Contractor shall provide specially made forms for use as sides to joints.

Shutters shall be provided for all slopes exceeding 15 degrees to the horizontal to enable the concrete to be properly placed. Formwork shall be constructed so that the side shutters of members can be removed without disturbing the soffit shutters and, if the Contractor wishes to leave some of the props in place when the soffit Shutters are removed, these props shall not be disturbed during the striking. The detailed arrangement for the props shall be submitted to the Engineer in advance of his approval.

Before any concrete is placed, the formwork shall be cleaned of all sawdust shavings and dirt and other debris washed out and all openings closed. The interior face of all formwork shall be carefully coated with an approved preparation to prevent the adhesion of the concrete thereto. This preparation must not be allowed to come into contact with the reinforcement and no organic oil will be permitted to be used to coat the forms.

All formwork shall be inspected and approved by the Engineer before any concrete is placed in it but such approval shall not relieve the Contractor of his responsibility for the safety, accuracy and efficiency of the work.

As shown on the drawings or where directed by the Engineer, blinding concrete shall be placed to the depth shown on the Drawings, in the foundation of footings of structures to provide a working platform and to protect the stability of the foundation soils. The area shall be sufficient to provide support for formwork.

Forms for exposed surfaces of walls and columns shall be metal to the approval of the Engineer and forms for all other exposed surfaces shall be constructed of plywood or metal, at the option of the Contractor.

All internal and external sharp edges and corners shall be chamfered to not less than 25 mm by 25 mm. Triangular fillets or chamfer strips shall be made of plastic or shall be milled from clear, straight grain lumber and shall be surfaced on all sides. Curved surfaces shall be formed of plywood, metal or other suitable, approved material.

Form clamps or bolts shall be used to fasten forms.

Bolts or form clamps shall be positive in action and shall be of sufficient strength and number to prevent spreading of the forms. Lifting anchors may be installed in precast members. Bolts, form clamps and lifting anchors shall be of such type that they can be entirely removed or cut back 30 mm or more below the finished surface of the concrete leaving no metal within 30

mm of the concrete surface. All forms for the outside surfaces shall be constructed with stiff wales at right angles to the studs and all form clamps shall extend through and fasten such wales.

No concrete shall be deposited in the forms until all work connected with constructing the forms and Placing all reinforcing steel, ducts, anchorages, or prestressing steel has been completed for the unit to be poured and the Engineer has inspected said form, reinforcing steel, ducts, anchorages, or prestressing steel.

If the concrete is to be prestressed, the falsework also shall be designed and constructed to support any increased or readjusted loads caused by the prestressing forces. Falsework or centering shall be founded upon a solid footing safe against undermining and protected from softening.

Openings shall be provided in forms to accommodate other work, including mechanical and electrical work. Support items required to be built into the forms shall be accurately placed and secured to avoid disturbance during concreting operations.

Drainage holes and weep holes shall be constructed as directed or as detailed on the Drawings. Forms for weep holes shall be as approved by the Engineer. No additional compensation will be allowed for this work.

704.01.4 Formwork, Embedded Articles - Sleeves, pipes or conduits of any non-reactive material located so as not to impair unduly the strength of the work may be embedded in the concrete with the approval of the Engineer.

Special care shall be taken to ensure that the article shall be securely fixed in the correct position and the Contractor shall at his own expense provide all necessary templates, temporary supports and other plant and labour required.

Items to be embedded in concrete shall be clean and free from oil or foreign matter that would weaken the bond of the concrete to these items.

The Contractor shall install in the formwork required inserts, anchors, expansion joint elements, sleeves and other items specified under other sections of these Specifications and shall co-ordinate installation with other trades in the proper location of such items. Ends of conduits, piping and sleeves embedded in concrete shall be closed with caps or plugs.

Tests on piping and other items which are required to be tested shall have been completed before starting concrete placement.

704.01.5 Removal of Formwork - The Engineer shall be informed in advance when the Contractor intends to strike any formwork and though the responsibility for the safe removal of the formwork rests with the Contractor the Engineer has the right to fix the time of striking if he decides this to be beneficial to the work.

The removal of formwork shall in all cases be supervised by an experienced foreman. All formwork shall be removed without such shock or vibration as would damage the concrete and before the soffit formwork and props are removed the concrete surface should be exposed, where necessary, in order to ascertain that the concrete has hardened sufficiently.

Any work showing signs of damage through premature loading is to be removed and entirely reconstructed at the Contractor's expense.

No separate payment shall be made to the Contractor for this work which will be deemed to be included in his rates for concrete.

Removal of forms and falsework shall not begin until the concrete has either obtained the minimum percentage of the 28-day design strength or until after the period shown below unless otherwise authorized by the Engineer.

<u>Falsework supporting</u>	<u>Period</u>	<u>Percentage Design Strength (minimum)</u>
Ramps, slabs or beams	7 days	80%
Walls	1 day	70%
Columns	2 days	70%
Sides of beams and all other vertical surfaces	1 day	70%

For cast-in-place post tensioned bridge superstructures, falsework shall remain in place until all post tensioning has been completed.

All formwork shall be removed from the cells of box girders.

To facilitate finishing, forms used for parapets, barriers and exposed vertical surfaces shall be removed in not less than 24 hours nor more than 48 hours, depending on weather conditions.

704.01.6 Stay-In-Place Forms - When the use of stay-in-place forms is permitted in the Contract, precautions shall be taken to prevent voids in the deck slab. Particular attention shall be paid to proper vibration and consolidation of the concrete.

704.01.7 Inspection of Stay-In-Place Forms - When steel stay-in-place forms are used, one form panel per fifty metres of bay length shall be removed after the first deck slab pour and prior to any subsequent deck pours. The form panels to be removed will be chosen at random by the Engineer. The chosen panels shall be removed as soon as possible after the concrete has attained eighty percent of the twenty-eight day design strength. Such removal shall be done by experienced workmen without shock or vibration which might damage the concrete. The concrete surface thus exposed shall be inspected for voids and honeycomb or other signs of improper concrete placement. Evidence of improper placement may warrant removal of additional form panels, at the discretion of the Engineer and measures shall be taken to correct the concrete placement procedures. Any voids or honeycomb shall be repaired as directed by the Engineer. Exposed form edges adjacent to the removed panels shall be free of ragged or unsightly edges. on subsequent deck pours the extent of form panel removal may be reduced, or form panel removal may be eliminated entirely at the discretion of the Engineer.

The Contractor shall "sound" all stay-in-place forms after concrete placement by tapping the forms with a light hammer in order to detect any voids. Voids will be assumed if a hollow or dull sound is obtained when the forms are tapped. To distinguish between voids in the concrete and moulded-in voids in certain types of form panels, the Contractor shall keep records detailing the location of all such moulded-in voids.

Sounding shall be performed in the presence of the Engineer. Any suspect areas discovered in this manner shall be exposed by the removal of as many form panels as deemed necessary by the Engineer to determine the extent of the void or honeycombed area. The removal of these forms shall be in addition to the random removal specified herein. Repairs shall be made as directed by the Engineer. In the case of asbestos cement or glass-fibre cement forms, or forms of any other such materials that tend to become an integral part of the deck due to bonding, repairs shall be made by removing only that portion of the form within the limits of the void.

704.01.8 Measurement and Payment

704.01.8.1 Measurement - No separate measurement shall be made for any size or shape of formwork and falsework (including stay-in-place forms).

704.01.8.2 Payment - No separate payment shall be made for any size or shape of formwork and falsework (including stay-in-place forms) which will be deemed to be included in the Bill of Quantities rates for the various items of concrete or other Works.

704.02 Steel for Reinforced Concrete

704.02.1 Drawings, Bending Diagrams and Bar Lists - Before ordering reinforcing steel the Contractor shall furnish detailed working drawings, bending diagrams and bar lists for the approval of the Engineer. Where appropriate the Contractor shall designate the Contract Drawings as his working drawings and submit these together with such other drawings as are necessary to expand the detailing required for accurate production of schedules and fixing of the reinforcement. Unless otherwise agreed with the Engineer, the Contractor shall adopt the same bar references in his bending diagrams and bar lists as indicated on the Contract Drawings, if such are provided. Bar lists shall show the weight of each bar, the total weight of each bar size and the total weight of bars on the list.

The approval of working drawings, bar lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such working drawings, lists and diagrams. Any expense incidental to the provision of material furnished in accordance with such working drawings, lists and diagrams to make it comply with the design Drawings shall be borne by the Contractor.

704.02.2 Samples - Before ordering reinforcing steel the Contractor shall submit for the Engineer's approval samples for testing from all proposed sources along with the Manufacturer's certificates indicating compliance with the Specifications. Source approval must be granted by the Engineer prior to site delivery. Following source approval and delivery to site, representative samples of all reinforcing steel that the Contractor proposes to use in the works must be sampled, tested and approved by the Engineer in writing before work is commenced. In addition the Manufacturer's certificates for each delivery shall be provided to the Engineer stating clearly for each bar size the place of manufacture, date and size of deliveries to site and all relevant details of composition, manufacture, strengths and other qualities of the steel and indicating compliance with the specified requirements.

Should a steel sample under test fail to meet the Specification requirements at any time or the Engineer considers that samples were not truly representative, or if it becomes apparent that reinforcing steel which has not been approved has been used on the works, then the Engineer

may instruct the Contractor to break out and remove completely all such sections of the work already constructed using such suspect reinforcing steel at no cost to the employer.

704.02.3 Storage and Protection of Materials - Reinforcing steel shall be protected at all times from damage by storing on blocking, racks, or platforms. Prior to placing concrete, reinforcing steel which is to be embedded, shall be free from heavy rust, dirt, mud, loose scale, paint, oil, or any other foreign substance.

704.02.4 Bending - All reinforcing steel shall be bent to the radius as given in the applicable standards unless otherwise noted on the drawings.

704.02.5 Placing and Fixing of Reinforcing Steel

- a. General** - The reinforcing steel shall be assembled to the shapes and dimensions as shown on the Drawings. The bars shall be of the cross-sectional areas indicated and shall be fixed rigidly and accurately in the forms in the positions shown on the Drawings. The bars shall be firmly bound together at intersections of bars to ensure that the reinforcement framework as a whole will retain its shape and the framework shall be so temporarily supported as to retain its correct position in the moulds during the process of depositing and consolidating the concrete.

The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface.

Spacing blocks approved by the Engineer shall be used to ensure accurate cover to the reinforcement where necessary and these blocks shall be of precast concrete of strength at least equal to that of the concrete being placed. They shall be as small as practicable and shall be securely fixed in position by means of wires cast into them. They shall be soaked with water immediately prior to concreting in. Alternatively, subject to the Engineer's approval of the type of spacer and its location within the structure, proprietary solid plastic spacer chairs of appropriate size may be used to provide cover to the reinforcing steel. Plastic spacers shall be securely fixed by tie wire.

Bundle bars shall be tied together at not more than 1.80 metre centres

Metal clips or supports shall not be placed in contact with forms or form liners.

No temporary supports to the reinforcing steel will be allowed to be incorporated in the finished concrete.

At the time of concreting all reinforcing steel shall have been thoroughly cleaned and freed from all loose rust, scale, mud, oil or any other coatings that might destroy or reduce the bond or induce corrosion and it shall also have been cleaned of all set or partially set concrete which may have been deposited thereon during the placing of a previous lift of concrete.

The placing of all reinforcing steel will be checked by the Engineer and in no case is concrete to be placed around any reinforcing steel that has not been approved by the Engineer. The insertion of bars into or the removal of bars from concrete already

placed will not be permitted. Reinforcing steel temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.

- b. Bridge Decks** - In bridge decks, reinforcing steel shall be fastened at alternate intersections unless this results in ties being more than 300 mm apart in which case each intersection shall be tied. The supports for reinforcing steel shall not be spaced more than 1.20 metres apart transversely or longitudinally. The placement of deck reinforcing steel shall not deviate more than 6 mm in the vertical direction, from the position shown on the Drawings. Concrete shall not be placed in any member until reinforcing steel placement has been approved by the Engineer.
- c. Splicing** - Except where shown on the Drawings, or approved shop drawings splicing will not be permitted without the approval of the Engineer.

Lap lengths shall be as shown on the Drawings or at 10 metre centres and shall conform to the requirements of the applicable standards approved by the Engineer.

Welding of reinforcing steel will not be permitted unless shown on the drawings or authorised in writing by the Engineer. All welds shall conform to the requirements of AAHTO Standard Specifications for Highway Bridges.

Dowels shall project a minimum of 50 bar diameters unless otherwise shown on the Drawings or directed by the Engineer.

Metal supports which extend to the surface shall not be used. Placing bars on layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted.

Main reinforcing steel carrying determinate stresses shall be spliced only where shown on the Drawings or on approved shop drawings.

Bar couplers will be permitted, subject to the written approval of details by the Engineer. Couplers shall be capable of developing the yield strength of bars jointed and, where appropriate, shall be of a type which will permit the splice to be made without the need to turn the bar.

704.02.6 Cover, Bar Sizes and Spacing - The cover to reinforcing steel, general limits on bar sizes and spacing of bars shall comply with the requirements of the applicable approved standards except as specified herein or where specifically noted otherwise on the Drawings.

704.02.7 Substitution - Substitution of different size bars will be permitted only upon specific authorization by the Engineer and the substitute bars shall provide a steel area equal or larger than that called for by the design. No additional compensation will be allowed because of the substitution of larger areas of steel.

704.02.8 Measurement and Payment for Reinforcing Steel

704.02.8.1 Measurement - Reinforcing steel bars incorporated in the concrete shall unless otherwise indicated, be measured in kilograms or in metric tonnes as applicable stating the type/grade of reinforcement (High Tensile steel bar (deformed)) based on the total

computed weight for the sizes and lengths of bars, as shown on the Drawings or authorized by the Engineer.

For computing the weight of reinforcing steel bars for payment, the theoretical weights shall be used.

No allowance will be made for clips, wire, separators, wire-chairs and other material used in fastening the reinforcing steel in place. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the amount specified shall be included.

For long bars the measurement will allow one lap at 10 metre centres unless the position of the lap is shown differently on the Drawings. When laps are made for splices, other than those shown on the Drawings the extra steel shall not be included.

704.02.8.2 Payment - The accepted quantities of reinforcing steel bars, determined as provided above, shall be paid for at the rates included in the Bill of quantities, which rates shall be full compensation for all labour, materials, equipment and incidentals required for proper installation and completion of the work.

Where reinforcing steel bars to be incorporated in concrete work involving reinforced concrete for which all inclusive items are prescribed in the Bill of Quantities for such work, the reinforcing steel bars shall not be measured nor paid for separately.

704.03 Mixing and Placing of Concrete

704.03.1 Continuity of Concrete Work - The Contractor must have sufficient quantities of approved materials, a batching plant of sufficient capacity and an adequate amount of hauling, placement and compaction equipment to ensure completion of any concreting operation in an efficient continuous operation. The Contractor shall provide sufficient equipment in reserve in case of breakdown.

The equipment available (as appropriate for the work in hand) must be approved by the Engineer prior to the start of concreting operation. It shall be the Contractor's responsibility to ensure that the Engineer's approval is sought and gained.

In the event of equipment breakdown or other unforeseen or unavoidable occurrence which causes, in the opinion of the Engineer, unacceptable delay in the concrete placement, a construction joint shall be constructed. The Engineer will designate if the joint is to be a plain or epoxy resin bonded joint or if it is to be an unbonded joint. No additional payment shall be made for such joints.

704.03.2 Batching and Mixing

- a. Location of Plants** - The location of the batching plants shall be agreed with the Engineer and the Contractor must submit to the Engineer for approval before erection of any batching or mixing plant his proposed arrangements for the storing of aggregates and the batching and mixing of the concrete. He must also submit details of the type or types of mixers and machines to be used and his proposals for conveying the mixed concrete from the mixer to the points of deposition.

b. Batching

- i. General** - Measuring and batching of materials shall be done in a batching plant.

Concrete shall be batched by weight and the weigh-batching machines used shall be of a type approved by the Engineer and shall be kept accurate and in good condition while in use on the works. Checks are to be made as required by the Engineer to determine that the weighing devices are registering correctly. Each mixer shall be fitted with a water measuring device having an accuracy within 1.0% of the quantity of water required for the batch and the measuring device shall be such that its accuracy is not affected by variations in the water supply pressure.

- ii. Portland Cement** - Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed.

All bulk cement shall be weighed on an approved weighing device. The bulk cement hopper shall be properly sealed and vented to preclude dust during operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it.

The accuracy of batching shall be within plus or minus 1.0% of the required weight.

- iii. Water** - Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over 1%.

Arrangements for the cooling of the mixing water shall be to the approval of the Engineer as will the handling of admixtures.

- iv. Aggregates** - Stockpiling of aggregates shall be in accordance with these Specifications. All aggregates produced or handled by hydraulic methods and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. In case the aggregates contain high or non-uniform moisture content, a storage or stockpile period in excess of 12 hours may be required by the Engineer.

Batching shall be so conducted as to result in a 2% maximum tolerance for weights of the required materials.

- v. Bins and Scales** - The batching plant shall include separate bins for the bulk cement, fine aggregate and for each size of coarse aggregate, a weighing hopper and scales capable of determining accurately the weight of each component of the batch.

Scales shall be accurate to 1.0% throughout the range of use.

- vi. **Admixtures** - Admixtures may be measured either by volume or by weight. The accuracy of measuring the admixture shall be within a range of error of not over 1%.

Independent equipment shall be used for measuring and adding each admixture to the mix. The dispenser shall contain a sight glass and an automatic mechanical cut-off device.

c. **Mixing**

- i. **General** - All concrete shall be machine mixed. Concrete may be mixed at the site of construction at a central point or by a combination of central point and truck mixing or by a combination of central point mixing and truck agitating.

Mixing shall be in accordance with the appropriate requirements by AASHTO M157 and as specified herein, except that in lieu of the Contractor providing an electronically activated revolution counter he may provide a mechanically actuated device as approved by the Engineer.

All mixing equipment shall be kept in good operational condition at all times.

- ii. **Mixers** - The mixing plant shall be of the drum or paddle box type and shall be approved by the Engineer. Continuous mixers will not be permitted.

Mixers having a rated capacity of less than 0.5 m³ shall not be used to batch structural concrete. Unless otherwise agreed by the Engineer the following procedure shall be adopted for mixing.

The batch shall be so charged into the mixer that a portion (approximately 10%) of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period.

Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall be not less than 60 seconds for mixers having a capacity of 1.5 m³, or less. For mixers having a capacity greater than 1.5 m³, the mixing time shall be not less than 90 seconds.

If timing starts the instant the skip reaches its maximum raised position, 4 seconds shall be added to the specified mixing time.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his own expense.

The concrete shall be mixed until a mixture of uniform colour and consistency is obtained.

The mixer shall be operated at the speed recommended by the manufacturer.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the mixer. On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean water. Any deposits of old concrete in the mixer shall be cleaned out by rotating clean aggregate and water in the drum before any fresh concrete is mixed. The aggregate and water shall be discarded.

Concrete mixed as specified above shall not be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

The concrete shall be mixed only in the quantity required for immediate use and concrete not in place within one hour from the time the ingredients were charged into the mixer, or concrete that has developed initial set, shall not be used.

Where approved by the Engineer, batched quantities of cement and aggregates may be transported from the batching plant to site and there mixed in a mobile or truck mixer. Where the cement and aggregates are combined or are in direct contact prior to mixing, batches will be rejected unless mixing takes place within 30 minutes of the combination or contact and if placing is not complete within 90 minutes of the combination or contact.

704.03.3 Delivery - Delivery of concrete shall be in accordance with the appropriate requirements of AASHTO M157 and as specified herein.

Immediately after mixing, the concrete shall be transported to the location of placing by methods which will prevent the separation, loss or contamination of any of the ingredients. Any method involving the use of pipes or chutes for transporting concrete will not be permitted, except with the written approval of the Engineer.

Transport of concrete from the mixers must be as rapid as possible and shall be so regulated that concrete placing is at a continuous rate unless delayed by the placing operations. Delivery shall be such that the interval between placing and compacting of batches shall not be so great as to allow the concrete in place to harden partially and in no case shall such an interval exceed 30 minutes.

704.03.4 Weather Precautions - When the shade air temperature is 35°C and rising, precautions shall be taken including:

- a. dampening the forms.
- b. reducing the concrete temperature to the lowest practical level by procedures such as:
 - i. shading the aggregates

- ii. cooling the mixing water before use
 - iii. screening the mixing plant and transporting vehicles from wind, rain and sun.
- c. erecting wind breaks and sunshades at the concrete placing location.
 - d. reducing the time between the placing of the concrete and the start of curing to the minimum possible.
 - e. minimising evaporation (particularly during the first few hours subsequent to placing the concrete) by suitable means such as applying moisture by fog spraying.

All precautions to be taken shall be subject to the Engineer's approval and the Contractor shall demonstrate that all approved precautions are available for use prior to the Engineer granting approval to any concreting operation.

The temperature of the concrete when placed shall not exceed 32°C, nor shall concrete be mixed or placed when the shade air temperature is 40°C or above or is expected to reach such a level during concreting, without special permission from the Engineer.

No concreting shall take place when the ambient temperature is below 0°C.

704.03.5 Concrete Consistency - The slump test, measured in accordance with AASHTO T119 shall be used as a check on the consistency of the concrete. The slump shall be no higher than necessary for proper placement and compaction and shall not vary by more than 40 mm from the slump agreed by the Engineer and the Contractor as being the accepted design slump for each particular approved mix.

704.03.6 Placing

- a. General** - Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer.

All formwork must be thoroughly cleaned of all dirt, shavings, loose stones etc. and all woodwork which will be in contact with the concrete shall be well soaked with water prior to commencing placing operations.

When the ambient temperature is 35°C or higher, reinforcing steel shall be shaded or kept cool by covering with wet hessian for a minimum period of 1 hour before the placing of concrete.

The method and sequence of placing concrete shall be as approved by the Engineer.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcing steel and under no circumstances shall concrete have a free fall of more than two metres. To convey the concrete as near as possible to its final position, drop chutes shall be used for small sections and bottom dump buckets or other suitable vessels for large sections. The concrete shall be placed so as to prevent water from collecting at the ends, corners or along the faces of the forms. and it shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form. All concrete shall be placed and compacted in even lifts with each batch adjoining the previous one.

The thickness of the lifts shall be between 150 mm and 300 mm for reinforced concrete and up to 450 mm for unreinforced concrete, the thickness depending on the width of forms, the amount of reinforcing steel and the necessity of placing each lift before the previous one commences to set, all as approved by the Engineer.

The concrete shall be carefully and continually compacted and worked around the reinforcing steel without displacing the bars and into the corners of the formwork so that it will be in close contact with the reinforcing steel and free from honeycombing.

After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcing steel.

Concreting in any one part or section of the work shall be carried out in one continuous operation and no interruption of concreting work shall be allowed without the approval of the Engineer.

Where beams and slabs together form an integral part of the structure, they shall be poured in one operation, unless provision is made to form a construction joint on the Drawings or as approved by the Engineer.

Concrete in columns shall be placed in one continuous operation unless otherwise permitted by the Engineer. The concrete shall be allowed to set at least 12 hours before piercaps are placed, unless otherwise shown on the Drawings.

Workers shall not be permitted to walk over freshly placed concrete until it has hardened sufficiently to carry their weight without distortion and great care shall be taken to ensure that reinforcing steel projecting from concrete recently placed is not shaken or disturbed so as to destroy or damage the initial set of the concrete in contact with it.

- b. Chutes and Associated Equipment** - Chutes shall be of rubber or metal except that the use of aluminium chutes, tremies, troughs and pipes will not be permitted.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place.

Where steep slopes are required, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement.

- c. Pneumatic Placing** - Pneumatic placing of concrete will be permitted if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete. Where concrete is conveyed and placed by pneumatic means the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 3 metres from the point of deposit. The discharge lines shall be horizontal or incline upwards from the machine.
- d. Pumping** - Placement of concrete by pumping will be permitted if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might

damage freshly placed concrete. Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

- e. **Compaction** - The concrete shall be compacted with approved mechanical or electro-mechanical poker vibrators, of a type approved by the Engineer, operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

Vibrators shall be capable of transmitting vibration to the concrete at frequencies of not less than 4500 impulses per minute (75 Hz) and visibly affecting a properly designed mixture with a 25 mm (1 inch) slump for a distance of at least 460 mm (18 inches) from the vibrator.

In all cases, not less than two vibrators in good operating condition shall be available at any site where concreting is taking place.

Over vibration shall not be allowed.

The poker vibrators shall have a diameter compatible with the spacing of the reinforcing steel and shall be properly handled by experienced personnel. They shall be immersed at regular intervals of approximately 10 times the diameter of the vibrator and to such a depth that the fresh concrete will be worked into that previously placed. Care shall be taken not to displace the reinforcing steel nor to disturb or affect partially set concrete. Vibrators shall not be attached to the reinforcement in any circumstances. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed.

All vibration compaction operations shall be completed immediately after the placing of concrete in its final position.

704.03.7 Protection of Placed Concrete - Freshly placed concrete shall be adequately protected from rain, storms, chemical attack and the harmful effects of sun, heat, wind, flowing water, vibrations and shocks. It shall also be fenced off or otherwise protected to prevent persons from walking thereon or articles being placed or thrown thereon. This protection shall continue until the concrete is sufficiently set such that it can no longer be damaged by these factors. The Engineer shall determine when the protection is no longer required but in any case this shall not be less than 24 hours after the time of placing.

704.04 Joints in Concrete Work

704.04.1 Construction Joints - Construction joints shall be made only at locations shown on the Drawings, as specified herein or approved by the Engineer.

Construction joints in abutment walls, wingwalls and barrels of box culverts shall be placed at intervals not exceeding 8 metres except as otherwise shown on the Drawings or approved by the Engineer.

The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation. Shear keys, formed into or out from the surface of the previously placed concrete, or steel dowels shall be used where required. Shear keys formed into the concrete shall be formed by the insertion and subsequent removal of bevelled wood strips which shall be thoroughly saturated with water prior to insertion. Steel dowels may, at the discretion of the Engineer, be used in lieu of keys. The size and spacing of the keys and dowels shall be as approved by the Engineer.

Care shall be exercised not to injure the concrete or break the concrete-steel bond at any time. In constructing bridge floors where longitudinal joints are specified, a platform shall be constructed outside the longitudinal joints and supported on the lower slab form and workmen shall not be permitted to stand or walk on the projecting reinforcement bars until the concrete has hardened.

a. Bonded Construction Joints - Except where otherwise specified, bonded construction joints where required shall be made using any of the following procedures:

i. Plain Joint - After the concrete has hardened so that the header board or form can be removed without damage to the concrete, it shall be removed and the cement paste removed from the surface by washing with water under pressure or by sandblasting to expose clean, well-bonded aggregate.

To facilitate the removal of the cement paste, the surface of the header board or form that shall be in contact with the first pour may be thoroughly covered with a retarder. The retarder shall be a ready-to-use liquid compound that delays the set of the surface concrete to facilitate the exposure of the aggregate and shall be approved by the Engineer in advance of the beginning of the work. It shall produce results satisfactory to the Engineer and shall be evaluated on the basis of the manufacturer's data and recommendations. When the retarder is used, washing with water under pressure shall be used to expose clean, well-bonded aggregate.

After the surface has been prepared, the concrete shall be kept saturated with water until the new concrete is placed, or it shall be saturated for a period of 4 hours before placing the new concrete. Immediately prior to the placing of new concrete, the forms shall be drawn tight against the concrete already in place and the horizontal surface shall be covered with a thin coat of 1 part cement to 2 parts sand mortar.

ii. Epoxy Resin Joint - After the header board or form is removed and the concrete has cured for the normal period, the second pour will be bonded to the first pour by the application of a two-component liquid polysulphide polymer epoxy resin concrete adhesive to the concrete joint surface. The epoxy concrete adhesive shall be a product approved by the Engineer.

The surface on which the adhesive is to be applied shall be free of oil, dirt and loose concrete. All unsound concrete should be removed until a base of strong, undamaged concrete is exposed on which to apply the adhesive. Heavy deposits of dirt or oil products shall be removed by wire brushing or sandblasting. The surface shall be free of moisture and dry before application of the adhesive. The adhesive shall not be applied to newly placed concrete before the normal curing period has elapsed.

The adhesive shall be applied in strict accordance with the manufacturers written instructions.

- b. Construction Joints in Bridge Decks** - Longitudinal and transverse bonded joints specified for bridge deck shall be constructed as specified for plain joint herein except use of a retarder shall be required when the cement paste is to be washed off with water under pressure.

Horizontal bonded construction joints when specified between the top of the bridge deck and the kerbs or parapets shall be constructed as specified for plain joint herein.

The Contractor, subject to approval of the Engineer, may pour a bridge deck full width with horizontal bonded construction joints between the deck and kerbs or parapets. The omission of longitudinal bonded joints will not be permitted if the Contractor does not have the necessary equipment or capacity for a satisfactory job.

- c. Unbonded Construction Joints** - Unbonded construction joints shall be made by forming or striking off the previously placed concrete to a true and even surface and allowing it to set. After the concrete has set, the new concrete shall be placed in contact with it and thoroughly compacted to secure a close contact between the old and new concrete at all points, with no attempt to secure a bonding of the new to the old work.

704.04.2 Expansion Joints - Expansion joints shall be as specified herein and as directed by the Engineer.

Unless otherwise shown on the Drawings or specified, expansion joints shall be installed as noted herein or as otherwise directed by the Engineer:

- a. For lined concrete drains (reinforced and non-reinforced) walls, channels etc, expansion joints shall be installed at intervals not exceeding 10 metres nor closer than 3 metres.
- b. For reinforced concrete culverts, retaining walls and similar structures, expansion joints shall be installed at intervals not exceeding 15 metres nor closer than 3 metres.
- c. For median and side barriers off structures, expansion joints shall be installed at 6 metre centres.
- d. For kerbs and paved areas of precast or in situ concrete, expansion joints shall be installed at intervals not exceeding 10 metres nor closer than 3 metres.

Unless otherwise specified in the Contract Documents, expansion joints shall comprise a 20 mm thickness of preformed non-extruding joint filler sealed with a polysulphide sealant all as specified herein.

With the approval of the Engineer, expansion joints may be adjusted in location to coincide with the Contractors intended construction joint locations.

Expansion joints in retaining walls shall be covered with two strips of torch applied waterproofing membrane protected with a PVC capping all as detailed on drawings and specified under sub-section 715 of this section of the Specifications.

704.04.3 Joint Fillers - Joint fillers shall be as specified herein and shall be installed in the locations shown on the Drawings, as specified herein or as directed by the Engineer.

- a. **Sponge Rubber and Cork** - Joint filler shall be a non-extruding and resilient non-bituminous preformed type conforming to the requirements of AASHTO M153. Type I -sponge rubber, Type II -cork, or Type III - self-expanding cork, as approved by the Engineer.
- b. **Expanded Polyethylene** - Joint filler shall be compressible closed cell foam sections or sheet. The load required to compress a test specimen to 50% of its thickness before test shall not be less than 0.12 N/mm² nor greater than 0.20 N/mm². Water absorption after six weeks total immersion shall not exceed 4% by volume.
- c. **Bitumen Emulsion Impregnated Fibre Board** - Joint filler shall comply with the requirements of AASHTO M213.
- d. **Bituminised Celotex** - Joint filler shall comply with the requirements of ASTM D1751.

The joint filler shall be cut to the same shape as that of the surfaces being jointed. It shall be firmly fixed against the surface of the concrete already in place in such a manner that it will not be displaced when concrete is placed against it. Expanded polyethylene shall be bonded into position using an adhesive approved by the Manufacturer. Immediately after form removal, the expansion joints shall be carefully inspected and any concrete or mortar that has sealed across the joint shall be neatly cut and removed.

704.04.4 Sealants - Sealants shall be as specified herein and shall be utilized as shown on the Drawings or as directed by the Engineer.

- a. **Polysulphide Sealant** - Polysulphide sealant shall be a two- component, cold curing polysulphide liquid polymer of an approved manufacture and shall be mechanically mixed. Application shall be in accordance with the Manufacturer's instructions especially in regards to the use of primers and cleaning of the joints.

Where polysulphide sealants are to be used directly against an existing bituminous surface, a suitable bond-breaker such as polyethylene tape shall be used against the bituminous surface to avoid contact with the sealant.

Unless otherwise shown in the plans, these sealants shall be used for joints in box culverts, median barriers, sewer works. etc.

Where bituminous materials are to be laid adjacent to a polysulphide seal, the polysulphide sealant shall first be allowed to cure completely, for a period of not less than two weeks, before the bituminous material is applied. In addition, a suitable bond-breaker such as polyethylene tape shall be applied to the sealant to isolate it from the bitumen.

- b. Elastomeric Sealants** - These shall be two-component, cold poured sealants meeting the requirements of BS 5212.

Application shall be in accordance with the manufacturer's instructions especially in regards to primers and cleaning of the joint.

Unless otherwise shown in the plans these sealants shall be used for joints in concrete pavements, slabs, etc.

- c. Hot Poured Sealants** - These shall be hot-poured meeting the requirements of either ASTM D3405, ASTM D3406 or BS 2499.

Application shall be in strict accordance with the manufacturer's instructions especially in regards to heating and reheating. Unless otherwise shown in the plans these sealants shall be used when jointing to asphalt pavement or other bitumen based materials.

704.04.5 Measurement and Payment

704.04.5.1 Measurement - There shall be no separate measurement for the furnishing and installation of joints in Concrete Work.

704.04.5.2 Payment - There shall be no separate payment for the furnishing and installation of joints in Concrete Work, the costs of which will be deemed to be included in the rates for the various concrete items in the Bill of Quantities.

704.05 Concrete Finishing Works

704.05.1 Finishing Concrete Surface - Classes of Concrete Finishes

- a. Class 1, Ordinary Surface Finish** - Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned and after having been kept saturated with water for a period of not less than three hours shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the grade of the concrete being finished. Mortar used in pointing shall be cured as specified. All expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform.

- b. **Class 2, Rubbed Finish** - Surfaces to receive a Class 2 finish shall be treated as for a Class 1 Ordinary Surface Finish except after the minimum time has elapsed for the pointing work for the Class 1 finish to have thoroughly set the concrete shall be kept saturated with water for a minimum period of three hours. Surfaces shall then be rubbed with a medium carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. The rubbing shall be continued until the entire surface is a smooth texture and uniform colour.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

Class 2 finish shall apply to all visible fair faced concrete surfaces.

- c. **Class 3, Surface Texture Treatment** - The Class 3 surface texture treatment shall be obtained by the use of form liners matching sample panels available for inspection at locations designated by the Engineer. Before ordering form liners, the Contractor shall submit samples of each form liner panel for selection and approval by the Engineer.

Form liner panels shall remain stable and free from distortion at temperature's up to 80°C. The form liners shall be set in the forms and used in accordance with the manufacturer's instructions. Care shall be taken when setting formwork to ensure that the depth of texture treatment is outside of the neat wall line providing the concrete cover to reinforcing steel as shown on the Drawings. Irregularities of pattern and holes in the final textured surface shall be patched with cement mortar and all stains shall be removed to the satisfaction of the Engineer either by wire brushing or by sandblasting.

- d. **Class 4, Fair Faced Finish for Exposed Concrete Surfaces** - The finish shall be smooth and of uniform texture and appearance, i.e. a "fair faced finish" and shall be obtained by the use of properly designed forms of closely-jointed material having a hard smooth surface. The particular material shall be used consistently throughout the structure.

The concrete surfaces shall be entirely free from stains, fins, lippings, nail or screw marks, raised grains or other blemishes. Any imperfections shall be made good as directed by the Engineer.

704.05.2 Measurement and Payment

- 704.05.2.1 Measurement** - There shall be no separate measurement for Class 1, 2, 3, or 4 finishes.

Special mold finishes shall be measured in square meters.

704.05.2.2 Payment - There shall be no separate payment for Class 1, 2, 3, or 4 finishes, the costs of which will be deemed included in the rates for the various concrete items in the Bill of Quantities.

704.05.3 Fixing of Ironwork - All brackets, rag-bolts and other ironwork for which holes have been boxed out or left in the concrete of a structure shall be carefully grouted in to their correct positions.

704.05.4 Reconstruction of Faulty Work - Should any member or portion of the work prove, after removal of the formwork, to be of inferior workmanship or to be in any way whatsoever defective, or should crushing tests on samples taken from the work show that the concrete used therein is of inferior quality, such work shall at the discretion of the Engineer be cut out and replaced at the Contractor's expense.

704.06 Curing - All new-placed concrete shall be cured and curing shall begin immediately and shall be continued throughout any finishing processes and for at least seven (7) days. Curing shall be done so that moisture is always present and shall be an integral part of the concreting operations. Improperly cured concrete will be considered defective and the Engineer will stop all of the Contractor's placing operations until proper procedures are put into effect.

When the air temperature is expected to fall below 2°C, the Contractor shall provide suitable measures to maintain the concrete surface temperature above 10°C.

One of the following methods of curing, or a combination thereof, shall be used except that the Engineer may require method a. for curing exposed surfaces:

- a. **Supplying Additional Moisture** - This method shall include supplying additional moisture by ponding, sprinkling, or fogging. Coverings such as burlap shall be used to retain water so supplied. The use of sawdust will not be allowed and coverings which cause unsightly discoloration of concrete shall not be used. Any method which results in the concrete being alternately wet and dry will be considered an improper curing procedure. Coverings shall be placed as soon as possible after finishing operations have been completed. The coverings shall be kept continuously moist.
- b. **Preventing Moisture Loss** - This method shall consist of preventing moisture loss from the concrete. It may be done with the use of approved waterproof paper, plastic sheets, or liquid membrane curing compound except where other requirements prohibit the use of these compounds. If a formed surface is to be rubbed, the concrete shall be kept moist before and during the and the curing shall be initiated immediately following the first rub while the concrete surface is still moist. Bridge decks, approach slabs, sidewalks and kerbs shall be covered with wet burlap or approved equal as soon as the concrete is sufficiently set to support this material without damage to the finish. This moisture-retaining material shall then be saturated with water and the entire area covered with waterproof paper or plastic sheeting.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

Membranes used to prevent moisture loss shall comply with the following:

- i. **Waterproof Paper** - The paper shall be the widest practicable width and adjacent sheets shall overlap a minimum of 150 mm and shall be tightly sealed with pressure sensitive tape, mastic, glue, or other approved methods to form a complete waterproof cover of the entire concrete surface. The paper shall be secured so that wind will not displace it. If any portion of the sheets be broken or damaged before expiration of the curing period the broken or damaged portions shall be immediately repaired. Sections which have lost their waterproof qualities shall not be used.
- ii. **Plastic Sheets** - The sheets shall be used in the same manner as required above for waterproof paper.
- iii. **Curing Compounds** - Only Type 2 liquid membrane curing compounds conforming to ASTM C309, may be used when approved by the Engineer as the initial and final curing agents on structural concrete subject to the following limitations:
 - (1) If the membrane film is broken or damaged at any time during the curing period, the area or areas shall be immediately recoated to the original requirements.
 - (2) Curing compounds shall be applied to unformed areas as soon as the water sheen has practically disappeared from the concrete, or immediately after the forms have been removed from surfaces not to be rubbed.
 - (3) Curing compounds shall not be used on surfaces receiving a rubbed finish or waterproofing treatment or on surfaces which are to receive an asphaltic concrete pavement overlay. In such cases a curing compound may be used but shall be thoroughly sand blasted to the approval of the Engineer prior to applying the required treatment or placing the pavement courses.
 - (4) If there is to be any delay in applying curing compound, the surface shall receive moist curing until the compound can be applied.
 - (5) Curing compound shall be applied with equipment which will produce a fine spray and all compounds shall be thoroughly agitated just prior to use. The surface shall be sprayed again immediately at right angles to the first application. The rate of each application shall be in accordance with the manufacturer's recommendations, but not less than 1 litre for each 3.6 m² of surface. Care shall be taken to prevent application to joints where concrete bond is required to reinforcing steel and to joints where joint sealer is to be placed.
 - (6) Curing compound shall be applied to bridge decks for initial supplemental curing. Type 2 or type I-D, Class B - lacquer based. compounds shall be used. The compound shall be applied immediately

after finishing as the initial surface sheen is disappearing from the concrete followed as soon as possible by a wet cure method. If deemed necessary by the Engineer prior to laying asphalt pavement on the deck the curing compound shall be thoroughly removed, except in the case of the type I-D, class B - lacquer based compound which can remain in place if shown to have good bonding qualities with bitumen products.

No separate payment shall be made for this work which will be deemed to be included in the rate for the various concrete items in the Bill of Quantities.

704.07 Measurement and Payment for Concrete

704.07.1 Measurement - Unless otherwise indicated measurement of plain and reinforced in-situ concrete shall be by the metre cube, stating the required Class and/or Strength of concrete measured overall and no deductions shall be made for the following:

- a. Volume of reinforcing steel or other items embedded in the concrete.
- b. Holes, pockets, sockets, mortices and the like less than 0.2 m³ in volume.

The volume of blinding concrete to be paid for will be measured between the limits shown on the Drawings.

U-strip shapes for luminaire base shall be measured as extra over quantity in square meters .

704.07.2 Payment - Payment for concrete shall be at the rate inserted in the Bill of quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including mixing, transporting and placing the concrete, vibrating as necessary, erecting and removing formwork (vertical or curved), curing, testing samples and test panels and all other incidental work in connection with the construction.

Forming or drilling holes, forming or cutting pockets, mortices and the like, furnishing and placing grout, furnishing and placing joint filler and sealer, tie bars, dowels, grout tubes, waterstops, waterproofing membrane strips at expansion joints, weepholes and the like shall be considered as incidental to the price paid for concrete work and no additional compensation will be allowed.

Except for special molds finishes that are itemized separately in the bill of quantities, no separate payment shall be made for all other surface finishes, including surface additives and hardeners to concrete which shall be deemed to be incidental to the work and to have been included in full in the rates for the work.

Where plain or reinforced concrete is included in other items of work for which all inclusive items are prescribed in the Bill of Quantities, plain or reinforced concrete shall not be measured or paid for separately.

U-strip shapes for luminaire base shall be paid as extra over quantity in square meters .including all necessary chamfers, joints and all other necessary materials and works to complete this item.

705 – PRECAST CONCRETE

705.01 General

705.01.1 Requirements - This Clause covers the requirements for ordinary precast concrete works. The class of concrete for each application is to be as specified herein or as shown on the Drawings.

All Clauses referring to cast in situ concrete shall apply to precast concrete and, in addition, the Contractor shall satisfy the Engineer that the precast concrete units are not moved or loaded until they have attained the requisite strength.

705.01.2 Transport, Storage and Erection - Units shall be so stored, transported and fixed that they will not be over stressed at any time or suffer any damage. Precast units shall be adequately braced and supported during erection to ensure proper alignment and safety.

The lifting methods for all precast members shall be to the approval of the Engineer and the Contractor shall submit details of any hook or lifting eyes he proposes to cast into the members. Such details shall include proposals for cutting the eyes or hooks from the precast members and for restoring the surface.

705.01.3 Finish - On removal from the moulds the precast concrete units shall be examined and all surfaces that will be permanently visible shall have a smooth and dense finish of uniform texture free from holes, fins and shutter staining and any precast concrete unit which is found to be defective in any respect shall be rejected.

705.01.4 Precast Products - The Contractor shall provide all requirements of kerbstones, edgestones, tiles, slabs, interlocking paving blocks and other precast elements of diverse sizes from approved production facilities or suppliers and shall transport them to the site of work by his own means of transport. The Contractor shall arrange for the manufacture of precast units under factory controlled condition and shall examine these materials before collecting from the factory and make sure that they are of good quality and conform to the Drawings and Specifications. The Contractor shall be responsible for any damage sustained by this material in the course of transportation or on site and the Contractor shall allow in his prices for all costs of manufacture, production, materials, labour, haulage, transportation from the factory, off-loading on site, waste and everything required for this work.

The Contractor is responsible for securing the required quantities at the proper time to fulfill the approved work programme and shall have no right to claim if there is any delay in the supply and/or delivery

The Contractor shall submit to the Engineer for approval full details of the design, manufacturing and production facilities, quality control and other data related to the production of precast concrete elements.

705.02 Bridge Infill Slabs

705.02.1 Description - This work comprises the laying of precast concrete infill slabs as permanent formwork between precast prestressed bridge beams.

705.02.2 General Requirements - Bridge infill slabs shall be manufactured from concrete Class B40 and shall be reinforced in accordance with the Drawings. Top surface of slabs shall be roughened to form a bonding surface with the insitu concrete bridge deck and shall have protruding reinforcement 'U' bars for handling and for tying in to bridge deck. Bottom surfaces shall be fair faced. Reinforcement shall comply with the relevant sections of this Specification. Size and thickness of slab shall be as detailed on the Drawings.

705.02.3 Measurement and Payment

705.02.3.1 Measurement – Infill slabs shall be measured by the meter cube for the size shown on the drawings.

705.02.3.2 Payment – Payments for the infill slab shall be at the rate inserted in the bill of quantities which rate shall include all incidental work in connection with the construction, all labour, materials, reinforcement, installation and equipment required.

705.03 Kerbstones

705.03.1 Kerbstones Sampling and Testing, - Kerbstones shall comply with the requirements of BS 7263.

705.03.2 Raised Flush and Transitional Kerbstones: Foundation, Haunching and Joints - The foundations to kerbstones shall be cast in situ to the dimensions shown on the Drawings. The Contractor shall make the necessary formwork on both sides and shall support it with vertical and horizontal props as per the required levels and setting out. The Contractor shall not be allowed to commence casting before obtaining the approval of the Engineer in respect of the formwork and casting shall be carried out in lengths not exceeding ten metre run separated by expansion joints. After soaking both kerbs and foundations with water, Kerbstones shall be constructed on the foundation with cement and sand (1:2) mortar, providing that the thickness of the mortar layer shall not exceed 30 mm unless otherwise shown on the Drawings. The vertical joints between the kerbstones shall be filled with the same mortar, pointed and cleaned with hessian. The Contractor shall make the necessary formwork for the front casting, if applicable and shall fix it well in position and carry out casting of concrete in accordance with the dimensions shown on the Drawings. After carrying out the front casting the Contractor shall execute the back casting (back fillet) in accordance with the same Specification as the front casting and over the remaining part of the foundation in back of the kerbs, all in accordance with the Specifications, Drawings and instructions of the Engineer

Expansion joints shall be provided at intervals of not more than 10 m and shall consist of pieces of Bituminised Celotex 10 mm thick complying with ASTM D1751 all in accordance with these Specifications, the Drawings and as directed by the Engineer. The joint shall be continuous through foundation, kerb, haunch and front casting and no off-setting of parts of the joint will be acceptable.

Curb openings in concrete channels shall be of opening size 600 x 200 x 100 mm high

705.03.3 Measurement and Payment for Kerbs

705.03.3.1 Measurement - Measurement of precast concrete kerbs shall be by the metre run, for each type, acceptably constructed in accordance with the Drawings and as instructed by the Engineer.

Curb openings in concrete channels shall be measured by number stating the size of opening.

Depressed sidewalks, including kerbs & tiles shall be measured in square meter as extra over.

705.03.3.2 Payment - Payment for precast concrete kerbs shall be at the rates indicated in the Bill of Quantities. Rates shall include for all labour, plant and materials and everything necessary for the proper execution of the Works including all necessary excavation of the kerb trenches, grading of trench bottom, upholding the sides of the kerb trench, removal of surplus excavated material, backfilling, concrete beds and backings, including any necessary formwork, providing and laying the kerbs including all transition kerbs, expansion joints, testing and all other incidental work in connection with the construction. Rates shall include for both straight and curved work.

Rates for depressed sidewalks shall include for all labour, plant, and materials including cost of kerbs, tiles and everything necessary for the proper execution of the work.

Rates Curb openings in concrete channels shall include for all labour, plant, and materials including cost of kerbs, tiles and everything necessary for the proper execution of the work.

705.04 Tiles/Paving Slabs

705.04.1 General - Cement, coarse and fine aggregates for precast concrete tiles and paving slabs shall comply with the relevant clauses of this section of the Specifications.

Paving slabs shall be 400 x 400 x 40mm thick with a patterned top surface to the approval of the Engineer. Slabs shall be made from Class B 25 concrete and shall comply with the requirements of BS 4131: 1973

In addition, tiles shall be tested for abrasion resistance to approved procedure. Result of abrasion resistance test should not exceed 0.75 mm when tiles are subjected to 1000 abrasive revolutions.

Before commencement of the work the Contractor shall submit to the Engineer for his approval a minimum of 10 No. paving slabs as a representative sample of the type of tiles and pattern to be used.

All units which are cracked, broken, warped, discoloured or improperly finished shall be rejected and promptly removed from site

705.04.2 Laying and Constructing precast concrete units shall be according to the following steps unless otherwise indicated:

- a. A bed layer of clean sand, average 50 to 100 mm thick shall be spread on the prepared substrate and water shall be added in order to obtain the required grades and levels before placing the tiles or paving units. Beach sand shall not be used.
- b. Units shall be placed directly on the sand or a layer of cement mortar as indicated or directed.
- c. In placing concrete units, care must be exercised so that no spaces shall be left between units. Sides of units shall be touching each other as close as possible.
- d. Units shall be secured in place using light compactors in order to achieve the proposed levels and grades.
- e. A thin layer of cement mortar shall be utilized as filler between units.
- f. Placing of units shall be carried out in lengths not exceeding 10 metre run separated by full depth expansion joints of pieces of Bituminised Celotex 10mm thick.
- g. Units shall be placed in a proper pattern and to suit the pattern of the tiles. Units less than full size may be cast in situ if approved by the Engineer.
- h. Additional or substitute pattern, if needed, can be used for laying units only after a written approval from the Engineer is obtained.

705.04.3 Measurement and Payment for Tiles/Paving Slabs

705.04.3.1 Measurement - Measurement of tiles/paving slabs shall be by the metre square for each type, over all edge stones and cement mortar filler, but excluding kerbs at roadways which are measured separately unless measured differently on the Bill Of Quantities. No deductions shall be made for voids or the like not exceeding 0.5 m².

705.04.3.2 Payment - Payment shall be at the rates inserted in the Bill of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including foundation and bedding layers, supplying and laying the units, providing and fixing all necessary expansion joints, associated edge stones, all cutting of tiles/paving slabs, cement mortar infill, trial areas, testing and all other incidental work in connection with the construction.

706 – INTERLOCKING PAVING BLOCKS

706.01 Description - This work comprises the laying of precast concrete interlocking paving blocks where shown on the Drawings and as specified herein.

706.02 Materials Requirements

706.02.1 Cement - Cement used for interlocking concrete blocks shall comply with these Specifications.

706.02.2 Coarse Aggregate - Coarse Aggregate used for interlocking concrete blocks shall comply with the gradation for prestressed concrete works, as specified.

706.02.3 Fine Aggregate - Fine aggregate used for interlocking concrete blocks shall comply with the specified requirements concrete.

706.03 Manufacture

706.03.1 General Requirements - All blocks shall be manufactured by an approved hydraulic press or mechanical vibration process resulting in a dense, compacted, homogeneous finished product.

Interlocking blocks shall be made from concrete Class B25 and shall be finished, transported and stored in accordance with these Specifications.

All interlocking blocks which are chipped, cracked, broken, warped, discoloured, improperly finished or which do not comply with dimensions and tolerances specified herein shall not be used in the Works and shall be promptly removed from the Site by the Contractor at his expense.

706.03.2 Approval of Blocks - Before commencement of the work, the Contractor shall submit to the Engineer for approval the following:

- a. A minimum of 12 No. of each type and shape of interlocking block required for the works including samples of coloured blocks when specified.
- b. Warranties from the Manufacturer regarding his ability to consistently attain the compressive strength, dimensional tolerances and surface finish requirements specified herein.

706.03.3 Dimensions and Tolerances - Interlocking paving blocks shall be of the shape and dimensions shown on the Drawings or directed by the Engineer.

Each side of the block shall be normal to the top and bottom faces of the block. The thickness of the block i.e. the dimension between the top and bottom faces of the block shall not vary by more than ± 3 mm from the specified thickness and measurements of thickness taken at any location within the plan area of the block shall not vary from each other by more than 1 mm.

706.04 Trial Areas of Interlocking Paving Blocks - Trial areas of interlocking paving blocks shall be constructed to determine the amount of bedding layer surcharge required. The trial area shall also demonstrate the pattern required for the works and construction method abutting manholes and traffic signs, etc.

Each trial area shall be approximately ten square metres. The blocks shall be laid to a pattern required for the works and designated by the Engineer. The construction materials and method shall be identical to that proposed for the Works.

The method of construction of the interlocking paving block areas as determined by the trial areas shall not be amended without the approval of the Engineer. Notwithstanding the acceptability of the trial area it shall be the Contractor's responsibility to ensure the finished interlocking paving block areas comply with the requirements of the Specifications.

706.05 Installation of Interlocking Blocks

706.05.1 Description - Laying interlocking blocks shall be in accordance with the following steps unless otherwise directed by the Engineer.

- a. The Contractor shall construct all edge restraints (Kerbs or sidewalk edgestone) prior to placing sand bedding layer and interlocking blocks
- b. The Contractor shall place a bedding layer of uncompacted, coarse, well graded sand over the prepared substrate. The depth of the uncompacted bedding layer including surcharge shall be as determined from the trial areas of interlocking blocks. The sand shall be spread to a uniform grade.
- c. Place the interlocking blocks in the pattern the Engineer has selected as close together as possible such that the spaces of the joints do not exceed 3 mm. The spaces shall be consistent so that the pattern as applicable remains constant.
- d. Tamp down and level the interlocking blocks with a mechanical plate vibrator until blocks are uniformly level, true to grade and free of any movement.
- e. At gully gratings, manholes or other such obstructions, the concrete blocks shall be carefully cut to fit. Small gaps left at the edges of the paved area, including against obstructions, shall be filled to the full depth of the paving block with 3:1 sand-cement mortar matching the colour of the-blocks and shall be fully compacted into the gap.

706.05.2 Cutting of Interlocking Blocks - If necessary, cutting of interlocking blocks shall be done with a block splitter or a concrete saw to obtain true, even and undamaged edges. Blocks with ragged or flaked edges shall not be accepted.

706.06 Acceptance Criteria for Levels, Grade and Evenness of Surface - The areas paved with interlocking blocks shall be checked for levels, grade and evenness of surface. Any areas not conforming to the requirements herein shall be taken up and re-laid at his expense.

The level of the finished surface at any point shall not vary by more than 10 mm from the required level. In addition the variation in falls of the surface shall not vary from the required values by more than 0.3%.

The evenness of the finished surface for flat areas shall be assessed by a 4 metre straight edge. When placed on the surface (in any orientation) the variation of the surface from the straight edge between any two contacts with the surface shall not exceed 6 mm. For contoured areas the acceptability of the evenness of the finished surface shall be judged by the Engineer on the basis of visual inspection. The Engineer's decision will be final.

706.07 Measurement and Payment

706.07.1 Measurement - Measurement of interlocking concrete paving blocks shall be by the metre square overall edge restraints and cement mortar filler but excluding kerbs of roadways which are measured separately. No deductions shall be made for voids or the like not exceeding 0.5 m².

706.07.2 Payment - Payment shall be at the rate inserted in the Bill of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including foundation and bedding layers, supplying and laying interlocking blocks, providing and fixing all necessary expansion joints edge restraints, cement mortar infill, testing and all other incidental work in connection with the construction.

No measurement and payment shall be made for trial areas of interlocking blocks. The cost of such work shall be included in the rates for the interlocking concrete paving blocks item in the Bill of Quantities.

707 – CONCRETE TESTING

707.01 General Requirements - In addition to all previously mentioned tests the following tests shall be carried out. All tests must be carried out in a manner as directed by the Engineer. The Contractor shall bear all expenses involved in obtaining cutting-out or sampling all specimens and/or component parts and for testing.

707.02 Test Cylinders - Works test cylinders shall be as specified for each new grade of concrete or for each 100 metre cube of concrete when the same grade is being used continuously, or as directed by the Engineer. Nine test cylinders shall be taken at each time and numbered consecutively and marked with the date, the section of work from which it was taken and any other information required and dispatched to the laboratory for testing for compressive strength. Nos. 1, 5 and 9 shall be tested after 7 days.

Nos. 2 and 8, 3 and 7 and 4 and 6 will be considered three individual samples or sets for testing at 28 days. If either of the cylinders in any set shows definite evidence, other than low strength, of improper sampling, moulding, handling, curing or testing, it shall be discarded and the strength of the remaining cylinders shall then be considered the test result for that set.

If the average of the three 7 day cylinders is below the minimum requirement the Contractor must immediately stop all concreting until checks are made on the material and equipment and immediately rectify any defect which has become apparent as the result of such checking. If so approved by the Engineer concreting may then continue entirely at the responsibility of the Contractor. However the Contractor may elect to remove and replace all defective concrete without waiting for the 28 day tests.

Final acceptance of the concrete work will be based on 28 days testing of the three sets of two cylinders each. The work will be considered in compliance if the average of the three sets equals or exceeds the minimum specified for the class of concrete being placed and if the average of the two in any one set does not fall below the specified minimum strength by more than 35 kg/cm.². If the result of the 28 day test is unsatisfactory, all concreting shall be stopped at the Contractor's expense and shall not proceed further without the written permission of the Engineer. The Contractor shall conduct tests in the suspect parts of the structure in such a manner as may be appropriate to the particular conditions or parts of the work. The concrete may be test loaded in situ or cylindrical test cores may be drilled out and tested in accordance with BS 1881. Should the tests prove that the concrete is unsatisfactory and/or below the standards specified, or should the Engineer judge that any sections of the

concrete works are defective, then the condemned concrete shall be cut out, removed and replaced by the Contractor at his own expense.

708 – BRIDGE STRUCTURES *(NOT APPLICABLE)*

709 – SEGMENTAL BRIDGE CONSTRUCTION *(NOT APPLICABLE)*

710 – APPROACH SLABS *(NOT APPLICABLE)*

711 – GROUT PADS *(NOT APPLICABLE)*

712 – WATERSTOPS

712.01 Construction Requirements - Waterstops shall be furnished and installed in accordance with the details shown on the Drawings, the provisions in these Specifications and as directed by the Engineer

Waterstops shall be provided by the Contractor at locations where ground or surface water is likely to seep through joints in the concrete from the face in contact with water to the exposed face.

Waterstops shall conform to the cross section and to the minimum dimensions shown on the Drawings or approved by the Engineer.

Waterstops shall be manufactured either from rubber, neoprene or from polyvinyl-chloride (PVC), at the option of the Contractor and to the quality or standard approved by the Engineer.

No splices will be permitted in straight strips. Strips and special connection pieces shall be well cured in a manner such that any cross section shall be dense, homogeneous and free from all porosity. All junctions in the special connection pieces shall be full molded. During the vulcanizing period the joints shall be securely held by suitable clamps. The materials at the splices shall be dense and homogeneous throughout the cross section.

If, after placing concrete, waterstops are materially out of position or shape, the surrounding concrete shall be removed, the waterstop reset and the concrete replaced, all at the Contractor's expense.

Field splices for neoprene waterstops shall be either vulcanised, mechanical, using stainless steel parts, or made with a splicing union of the same stock as the waterstop, at the option of the Contractor.

Field splices for polyvinyl-chloride waterstops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not char the plastic.

Waterstops when being installed shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

Field splices shall develop watertightness equal to that of the unspliced material and have a tensile strength of not less than 50% of the unspliced material.

712.02 Measurement and Payment

712.02.1 Measurement - No separate Measurement will be made for waterstops and all work including furnishing and placing.

712.02.2 Payment - No separate payment will be made for waterstops and all work including furnishing and placing is deemed to be included in the rate for concrete items in the Bill of Quantities.

713 – STRUCTURAL STEEL WORKS INCIDENTAL TO CONCRETE WORKS

713.01 General - All structural steel in these Specifications or shown on the Drawings shall conform to the requirements of approved standards and all welding shall be performed in accordance with these standards by experienced welders as approved by the Engineer.

713.02 Measurement and Payment

713.02.1 Measurement - The furnishing and installing of structural steel incidental to concrete work as shown on the Drawings and specified will not be measured.

713.02.2 Payment - The furnishing and installing of structural steel incidental to concrete work as shown on the Drawings and specified will not be paid for but will be considered a subsidiary obligation of the Contractor under the various items of work included in the Bill of Quantities.

714 – MISCELLANEOUS CONCRETE STRUCTURES

714.01 General - The work included herein provides for construction of miscellaneous concrete structures such as roadway median and side barriers, all in accordance with these Specifications, as shown and detailed in the Drawings and as directed by the Engineer.

The Class of concrete to be used for each type of structure shall be as indicated. Structure excavation and backfill shall meet the requirements of these Specifications.

714.02 Roadway Median and Side Barriers off Structures

714.02.1 General Roadway Requirements - Concrete roadway median, side barriers of structures and concrete parapets shall be constructed in cast-in situ or precast reinforced concrete barriers fixed to the ground as shown on the Drawings, and as specified in this Specifications Section. Where shown on the Drawings and indicated in the Bills of

Quantities, removable type barriers shall be precast concrete and include lifting devices and accessories. Forms shall be smooth and tight fitting which can be held rigidly to line and grade during placing of concrete and which can be readily removed without injuring the green concrete.

At the option of the Contractor, median and side barriers may be precast in sections. The method of casting, handling and placing barrier sections shall be as approved and directed by the Engineer

Details of any reinforcement required in precast barriers to facilitate handling are to be prepared by the Contractor for the Engineer's approval.

Barrier expansion joints, as detailed on the Drawings, shall be placed at intervals not to exceed 6.0 metres, except as directed by the Engineer. Preformed joint filler and sealer shall conform to the requirements for expansion joints as specified herein and styrofoam backup rods shall be as detailed for precast barrier joints

714.02.2 Measurement and Payment

714.02.2.1 Measurement – Median, side barriers and concrete parapets shall be measured separately by meter run.

714.02.2.2 Payment - Payment for (the fixed type) barriers and the concrete parapets shall be at the rate included in the Bill of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including but not limited to excavation of trenches, grading of trench bottom, blinding where shown on the Drawings, upholding the sides of the trench, removal of surplus excavated material, backfilling, providing and fixing the barriers whether in situ or precast concrete with all necessary formwork, forming expansion joints as required, testing and all other incidental work in connection with the construction.

Payment for (the removable type) barriers shall be at the rate included in the Bill of Quantities which rate shall include for all labour, plant and materials and everything necessary for the proper execution of the work including but not limited to, blinding where shown on the Drawings, transportation, storage, handling and installing the barriers, barriers lifting devices and accessories, and all other incidental work in connection with the construction.

Payment for reinforcing steel required in barriers will be considered included in the rates for median, side barrier and concrete parapets shown in the Bill of Quantities and no additional payment will be made for steel reinforcement of the barriers.

715 – BRIDGE DECK WATERPROOFING

715.01 Bridge Deck Waterproofing Coating

715.01.01 Description

This work consists of preparing surfaces for and applying a protective membrane on the structural slab of bridge decks. The membrane shall serve as a waterproof barrier to be overlaid with asphaltic concrete.

715.01.02 Materials

1. Requirements

- Provide a membrane system that conforms to Tables 1.1 and 1.2.
- Use a waterproofing membrane that incorporates a high strength, heat resistant woven fabric embedded in a layer of self-adhesive rubberized asphalt. The membrane shall offer a complete and interlaminary adhesion by bonding to both the substrate and the hot bituminous overlay.
- Use a water-resistant primer adhesive that is supplied by the manufacturer of the membrane or other approved equal compatible with the membrane.
- Ensure that the membrane contains at least 14 percent synthetic rubber by weight.
- Use an approved sealant compatible with the membrane and primer as mastic.

Table 1.1- Membrane Properties

Membrane Properties	Test Method	Typical Value
Thickness	ASTM D 3767	1.7mm minimum
Tensile Strength	ASTM D 882	13 kN/m 7928 kPa
Elongation, Ultimate Failure of tar mass	ASTM D 882	50% minimum
Puncture Resistance, Mesh	ASTM E 154	890 N
Flexibility, 180° bend over 6mm mandrel at -4°C	ASTM D 1970	Unaffected
Crack Cycling at -4°C, 100 Cycles	ASTM C 836	Unaffected
Permeance	ASTM E 96	58 ng/m ² sPa
Peel Adhesion	ASTM D 903	880 N/m

Table 1.2- Membrane Characteristics and Requirements

Characteristic	Requirement
Bond	No break in bond, curled edges, bubbles, or pinholes.
Water Permeability	Above 5.4 megaohms/m ² measured indirectly in ohms per square meter.
Heat resistance	Withstand 150°C and retain an electrical resistance above 5.4 megaohms/m ² .
Resistance to aggregate	Retain an electrical resistance above 5.4 megaohms/m ² after granite.
Penetration	Chip creep damage test for 20 hours at 60°C.
Resistance to freeze-thaw cycles	After 10 cycles of freezing and thawing, the test membrane shall have the tensile strength of similar samples of the same membrane unfrozen.
Chemical resistance	Remain intact and in good condition when immersed for 30 days in each of the following inorganic acids, alkalies, and salts: <ul style="list-style-type: none"> • 5% sulfuric acid • 5% hydrochloric acid • 5% sodium hydroxide • 25% sodium chloride • 25% calcium chloride
Resistance to shear	Have a shear resistance of 45 kg.
Waterproofing effectiveness	The membrane system does not displace; retain an electrical resistance above 5.4 megohms/m ² .

715.01.03 Preparation

Cure new bridge decks that will receive waterproofing membrane according to the Specifications without using membrane-forming curing compounds or linseed oil treatments.

Prepare concrete surfaces receiving waterproofing as follows:

1. Chip or grind smooth high spots, sharp points, and edges on the deck surface.
2. Fill holes and depressions in the concrete surface flush with mortar. Mortar shall be composed of one part Portland Cement and two parts sand. Approved commercially produced, fast setting grout may be used to expedite the work.

Approved, commercially produced, fast setting grout may be used to expedite the Work.

3. Allow the mortar to cure.

4. Clean and remove all traffic paint and other harmful materials from the deck by sand-blasting the entire deck surface to which the waterproofing membrane will be applied.
5. Remove all sand-blasting residue with compressed air. Do not use water to clean the deck.

715.01.04 Construction

Use the following guidelines:

1. Observe weather conditions.

Do not perform the work when the relative humidity is above 80 percent or when rain is imminent.

Prime surfaces and place membrane only when the air and concrete surface temperatures are above 10°C and the surface is thoroughly dry.

2. Prime the Surface

Prime the surface as follows:

- a) Ensure that the concrete decks are at least 14 days old before applying prime and membrane.
- b) Prime and cure all areas that will receive membrane according to the manufacturer's recommendation or as directed by the Engineer.

3. Place the Waterproofing Membrane

Place the Waterproofing Membrane as follows:

- a) Unless otherwise designated on the Plans, extend the waterproofing membrane at least 150mm up the faces of the curbs, parapets, and barriers in the transverse direction and to the outer limits of the expansion joints in the longitudinal direction.
- b) Apply the membrane to the deck surface using either hand methods or mechanical applicators.
- c) Apply the membrane to the concrete deck so that it forms a butt joint with the faces of open joints and at expansion devices and other joints.
- d) Seal the edges of the membrane and the drain openings to prevent water from passing between the waterproofing and the surface it covers.
- e) Install preformed sheet membrane in a shingled pattern so that water can drain to the low areas of the deck without accumulating against seams.
 - 1) Roll the preformed sheet membrane into place with a lawn-type roller to minimize air bubbles and to ensure that the membrane bonds with the primed surface and bonds at the overlaps.

- 2) Overlap each strip of preformed sheet membrane at least 100mm.
- 3) Place the membrane so that end laps are in the direction of the paving operation.
- f) Eliminate air bubbles by puncturing the membrane and forcing the air out.
- g) Repair these holes and other ruptures as recommended by the manufacturer. Extend patches at least 150mm beyond the defect.
- h) Completely open all drain holes in the deck where called before paving over them.

4. Place the Pavement

Place the pavement as follows:

- a) Do not allow construction traffic over the waterproofing membrane before placing the surface pavement.
- b) Apply the paving over the membrane.
- c) Completely open drain holes in the deck after placing the pavement course.

5. Applying Bituminous Overlay

When covering the membrane with a bituminous overlay, maximum aggregate size should not exceed 13mm. Asphalt application temperature should range between 135°C and 150°C.

Only vehicles necessary for the overlay or paving operations shall be on the membrane.

The Contractor shall be responsible for maintaining the condition of the waterproofing membrane until it is covered with pavement.

Apply bituminous overlay as follows:

- a) Before placing the overlay and if required, apply a bond coat of adhesive (bituminous tack coat) to the surface of the waterproofing membrane according to the membrane manufacturer's recommendations.
- b) Overlay the waterproofing membrane with the thickness or quantity and the type of asphaltic concrete specified on the drawings.

Bituminous overlay application shall begin as soon as possible after the membrane and, if required, after the bond coat are placed.

- c) Dump the asphalt concrete directly into the receiving hopper of the paving machine.
- d) Have the truck pull forward and avoid contacting the paving machine while it is moving.

- e) Do not permit the mixture to be dumped onto the deck ahead of the paving machine.
- f) Spread and roll the asphalt concrete so that the membrane will not be damaged. Roll the first asphalt concrete lift with a breakdown roller as soon as possible after the paving machine has passed. Do not permit the use of vibratory rollers with the vibrator on.
- g) Compact the asphaltic concrete to the satisfaction of the Engineer and the applicable compaction requirements in the specification.

715.01.05 Measurement

Bridge deck waterproofing membrane and mortar if required, complete in place and accepted, will be measured by the number of square meter of bridge deck. Material placed in curb faces and overlaps will not be measured.

Asphaltic concrete and bituminous tack coat asphaltic concrete will be measured and paid for as provided under their respective items.

715.01.06 Payment

Bridge deck waterproofing membrane will be paid for at the Contract Unit Price per square meters for preparing surfaces and for furnishing and applying the waterproofing system.

715.02 Waterproofing membrane for Underpass-Overpass cover slab and walls

715.02.01 Description

A. Unless otherwise indicated and approved by the Engineer, the extent of membrane waterproofing includes but is not limited to the furnishing and placing of torch applied and self-adhesive waterproofing membrane as applicable to the Contract and as shown on drawings and specified hereinafter:

1. Waterproofing Membrane:
 - a. On all horizontal surfaces of footings and base slabs as indicated on drawings.
2. Waterproofing Membrane with Protection Sheet: On all vertical surfaces of base slabs, footings, grade beams, and portions of walls which are below finished grade level.

715.02.02 Quality Assurance

A. Manufacturer of Materials: A reputable firm with not less than 10 years successful experience in producing the type of materials specified and required for this project. Obtain membrane waterproofing materials from only one manufacturer, to the greatest extent possible.

B. Codes and Standards: Comply with the applicable requirements of the following:

ASTM American Society for Testing and Materials

UEAtc European Union of Technical Agreement

DIN Deutsches Institut für Normung

715.02.03 Submittals

A. Manufacturer's certificates: Submit manufacturer's certificates and laboratory test reports certifying that all materials and products comply with the specified requirements.

B. Installation Instructions: Submit manufacturer's installation instructions, indicating preparation of substrates and application of membrane and protection sheet.

C. Shop Drawings: Submit shop drawings, showing layout of sheets, location of splices, types of splices and termination details.

D. Samples: Submit 300 mm square samples of waterproofing membrane and protection sheet and vapor barrier. Samples will be reviewed for colour and texture only by the Engineer. Compliance with all other requirements is the exclusive responsibility of the Contractor.

715.02.04 Product Handling

A. Deliver materials in manufacturer's unopened, labeled containers, and comply with manufacturer's installations for storage and handling.

715.02.05 Job Conditions

A. Proceed with installation only when existing and forecasted weather conditions will permit the work to be performed in accordance with manufacturer's instructions.

715.02.06 Materials

Materials shall be as shown on drawings.

A.1 Self-Adhesive Waterproofing Membrane: Self-adhesive cold applied modified bituminous waterproofing membrane, shall be rot-proof, polyester laminated, fibreglass reinforced with a polymer modified rubber compound conforming to Table 2.1 hereafter.

Table 2.1-Self Adhesive Cold Applied Waterproofing Membrane

<u>Properties</u>	<u>Typical Values</u>	<u>Test Method</u>
Reinforcement	60 g/m ² reinforced fiberglass fleece	UEATc
Tensile Strength of Reinforcement Longitudinal Transverse	20 N/mm ² 13.3 N/mm ²	ASTM D412
Elongation or rubber modified bitumen compound	> 2000%	ASTM D412
Lap joint tensile strength Longitudinal Transverse	> 250 N/5cm > 175 N/5cm	UEATc
Tear Resistance Longitudinal Transverse	35 N 45 N	ASTM D1004
Tensile – Tear Strength Longitudinal Transverse	116 N/mm 112 N/mm	ASTM D4073
Peel Strength To primed concrete To self To metal	2.01 N/mm 2.11 N/mm 5.7 N/mm	ASTM D1000
Resistance to hydrostatic pressure	5 Bar	DIN 1048
Puncture resistance	245N/60 mm (Not perforated at 25kg)	ASTM E 154, UEATc
Softening point	100 °C Min.	ASTM D36
Penetration at 25°C	80 – 100 dmm	ASTM D5
Flexibility at low temperature	-15 °C – No cracking	ASTM E 146, UEATc
Water absorption	0.12%	ASTM D570
Chemical resistance	Conforms	ASTM D543

A.2 Torch Applied Waterproofing Membrane: Torch-applied waterproofing membrane shall be coated with a formulated mixture of SBS modified bitumen or APP polymer modified bitumen. The SBS modified bituminous membrane may be plain or slated as required. Torch applied waterproofing membrane shall be either of APP (atactic polypropylene) modified bitumen reinforced membrane conforming to Table 2.2 or SBS (Styrene Butadiene Styrene) modified bitumen conforming to Table 2.3.

**Table 2.2- APP Modified Bituminous Membrane
(Resistant to Water Born Chemical Attack)**

<u>Properties</u>	<u>Values</u>	<u>Test of Method</u>
Nominal thickness	4 mm	--
Softening point (R+B) of Coating Mixture	155 ⁰ C	ASTM D36
Penetration of coating mixture	12 – 20 dm	ASTM D5
Flexibility at low temperature	-2 ⁰ C– to 5 ⁰ C	UEATc
Service Ambient Temperature	-10 ⁰ C to 100 ⁰ C	--
Tensile Strength Longitudinal Transverse	750 N/5cm 550 N/5cm	UAETc
Elongation Longitudinal Transverse	40% 45%	UAETc
Puncture Resistance Static Dynamic	L4 I4	UAETc
Reinforcement core of membrane	180g/m ² Polyester (Non-woven)	--
Resistance to Water Pressure (24 hr)	> 60 kpa	UAETc
Resistance to Thermal Ageing	Complies	UAETc
Resistance to Ageing due to UV Radiation	Complies	UAETc
Water Vapor Permeability	<0.2g/ 24 hr/ m ²	ASTM E 96

Table 2.3- SBS Modified Bituminous Membrane

<u>Properties</u>	<u>Typical Values</u>	<u>Test Method</u>
Nominal thickness	4 mm	--
Reinforcement Base	180 gms/m ² non woven spunbond Polyester mat	--
Softening point (R+B) of coating mixture	≥ 135 ⁰ C	ASTM D36
Penetration (DOW) of coating mixture	35-45 dm	ASTM D5
Flexibility at low temperature	-10 to 20 ⁰ C	UEATc
Service ambient temperature	80 ⁰ C to -40 ⁰ C	--
Tensile Strength Longitudinal Transverse	850 N/5 cm 700 N/5 cm	UEATc
Elongation Longitudinal Transverse	50% 55%	UEATc
Lap Joint Strength Longitudinal Transverse	850 N/5cm 700 N/5cm	UEATc
Tear Resistance Longitudinal Transverse	270 N 270 N	UEATc
Puncture Resistance Static Dynamic	L 4 (not perforated at 25 kg, 10 mm ball), I 4 (not perforated at 9 joules impact energy, 5mm ball)	UEATc
Heat Flow Resistance, 100 ⁰ C, 2HRS	No Flow	UEATc
Water Absorption	Less than 0.15%	ASTM D570
Impermeability of the Membrane of water	Absolutely Impermeable	UEATc
Resistance to Thermal Ageing	No signs of deterioration after the test	UEATc
Resistance to Thermal Ageing due to UV-Radiation	No signs of deterioration after 2000 hours	ASTM G53
Water Vapour Permeability	Absolutely Impermeable	ASTM E96
Hydraulic Pressure Resistance	> 110 PSI	DIN 1048

B. Primer: Compatible with the type of the waterproofing membrane and as recommended by manufacturer.

C. Protection Sheet: Mineral finished bitumen felt not less than 4 mm total thickness coated on one side with self adhesive rubberized bitumen compound and rolled with release paper to permit pressure sensitive application. Provide sheets that are suitable for use with the membrane and for underground use as recommended by the manufacturer.

D. PVC Fillet: Provide preformed triangular PVC extrusion 40 mm coated with self adhesive compound.

715.02.07 Installation

A. Waterproofing Membrane:

1. General: Install waterproofing membrane on prepared, even, smooth and dry substrates. Ensure that substrates are thoroughly cleaned from any dust or loose material. Remove all projections, sharp edges and patch all holes, local depressions and sudden changes, and ensure that construction operations do not puncture the membrane. Seal joints in membrane and seal to other surfaces at extremities of coverage by lapping and bonding.

Membrane shall be applied when the humidity is less than 85%.

2. Laps and Corners: Provide not less than 150 mm side and end laps. At internal and external corners, provide additional membrane strips and carry out cutting and fitting of the membrane as recommended by manufacturer to achieve suitable and watertight construction.

3. Fillets: Where indicated and at internal corners install PVC fillets forced tightly into the corners and apply an additional 300 mm wide reinforcing strip of waterproofing membrane.

4. Primer: Carry out application of primer evenly on prepared substrates in accordance with manufacturer's recommendations.

5. Application of Waterproofing Membrane:

- a. Install self –adhesive waterproofing membrane by peeling back the protective paper and unrolling adhesive surface on to the prepared substrates. Ensure that air is excluded from under the membrane and all joints adequately overlapped providing a continuous adhesion and watertight construction.

Install torch-applied waterproofing membrane so that the underside of the membrane is properly torched just enough to superficially melt the bitumen. Excessive heating may damage the reinforcement. Overlaps should be re-heated from the top and resealed with a trowel to ensure seam integrity.

Application of waterproofing membrane shall also be in accordance with manufacturer's recommendations.

B. Application of Protection sheet:

1. Provide the required protection for the waterproofing membrane including the application of protection sheet for the waterproofing membrane applied to concrete surfaces below grade to the extent indicated and required. The earth fill next to the foundations shall not contain pieces of stone bigger than 50mm in any dimension and the filling and compaction operations shall not be conducted in a manner that may damage or puncture the waterproofing membrane.

2. Carry out the installation of the protection sheet by progressively unrolling sheets in a similar manner as the membrane. Stagger all longitudinal joints at right angles to the lap

joints in membrane below, provide not less than 75 mm wide side laps and 150 mm end laps and ensure continuous adhesion and watertight construction. Extend protection sheet as indicated well dressed over waterproofing membrane and tucked in preformed reglets and sealed.

715.02.8 Measurement

Waterproofing membrane for underpass cover slab and walls will be measured by square meter.

715.02.9 Payment

Waterproofing membrane for underpass cover slab and walls will be paid for at the Contract Unit Price per square meters for preparing surfaces and for furnishing and applying the waterproofing system.

716 – PROTECTIVE PAINTING OF CONCRETE

716.01 General - The following Specification covers the furnishing and application of rubber bituminous emulsion coating or (epoxy resin coating system) to buried surfaces of concrete and external quality emulsion paint to exposed surfaces of concrete as detailed and shown on the Drawings and directed by the Engineer.

716.02 Submittals - The Contractor shall submit to the Engineer for approval three samples in one liter containers of each of the protective paints.

The Contractor shall submit to the Engineer certificates that the materials to be furnished comply with the Specification requirements.

716.03 Rubber Bitumen Emulsion

716.03.1 Materials - The rubber bitumen emulsion shall be a water bound emulsion with a minimum 60% total solids content by volume, comprising bitumen with fine particles of rubber. Not less than 10% nor more than 20% of the total solids shall be rubber. The consistency shall be such that it can be applied to the surface by brush at normal temperature.

716.03.2 Application - Before the application of rubberized bitumen emulsion the concrete surfaces shall be thoroughly cleaned and made free from dirt, dust, grease and other extraneous matter and lightly brush dampened immediately prior to application of the emulsion.

The priming coat shall be made up by mixing 0.23 kg of approved powder detergent or the equivalent of liquid detergent, with 45 litres of clean water and adding this to 4.5 litres of emulsion. The priming coat shall be applied at the approximate rate of 9 litres per 30 m².

The second coat consisting of undiluted emulsion shall be applied as soon as the priming coat is dry, at the approximate rate of 9 litres per 15 m².

The emulsion shall be applied by brush, squeegee or spraying strictly in accordance with the manufacturer's instructions, It shall not be applied during or when rain or dust storms are to be expected.

Backfilling shall not be commenced until the second coat of emulsion is quite dry.

716.04 Epoxy Resin Coating System

716.04.1 Materials - The epoxy resin coating system shall consist of two component solvent free, liquid epoxy resin modified with refined coal tar pitch, conforming to ASTM C881:Type III: Grade 2: Class C or to BS 5493. It can be applied to the surface by brush, short hair roller, or by airless spray at normal temperature.

716.04.2 Application - Before the application of rubberized bitumen emulsion the concrete surfaces shall be thoroughly cleaned and made free from dirt, dust, grease and other extraneous matter. Before start of coating application, concrete surface should be allowed to dry for 5 days and physical test to be performed using a moisture-tester to prove that percent

moisture in concrete surface does not exceed 5% or the value allowed by the manufacturer of coating.

Primer: shall be used if required by manufacturer's Instructions.

Coating: shall be applied in two coats to achieve a minimum DFT of 300 microns.

Application steps should be made as per product data sheet and manufacturer's instructions.

716.04.3 Tests

Adhesion Test: A test certificate from an approved testing agency should be submitted to the engineer proving that when three pull-off tests ASTM D 4541 are performed, all test failures should occur at substrates or binder levels. If only one test, out of three, records a failure within the coating, the pull-off strength value measured should not be lower than 1 N/mm².

716.05 External Quality Emulsion Paint

716.05.1 Materials - External quality emulsion paint shall be based on acrylic copolymer dispersions and shall provide a highly durable, washable, protective coating suitable for use on external concrete surfaces. The paint shall be resistant to the ill effects of a saline and urban environment, oils, greases and to the alkalinity of concrete. Paint colour shall be selected by the Engineer.

716.05.2 Application - Surfaces must be solid, clean and dry, free from oils, greases, salt, dirt and other contaminants prior to the application of the emulsion paint. Blistered or chalky substrates must be cleaned properly and rebonded by a priming coat. All newly laid concrete must be pre-treated with a 5% solution of Muriatic acid and all holes and irregularities must be filled with an approved grouting material. Before start of coating application, concrete surface should be allowed to dry for 5 days and physical test to be performed using a moisture-tester to prove that percent moisture in concrete surface does not exceed 5% or the value allowed by the manufacturer of coating.

All surfaces should be primed with a clear sealer as recommended by the manufacturer and a second undiluted coat of emulsion applied in accordance with the manufacturer's instructions.

Emulsion shall be applied by brush or spray as recommended by the manufacturer but no painting shall be carried out when rain or dust storms are expected.

716.05.3 Testing and acceptance Criteria

UV light Resistance: Since the coating is exposed to UV Light action, Contractor should provide a test certificate, from an approved testing agency, proving that the proposed Acrylic Copolymer coating does not fade or change color when subjected to ASTM G53 at an accelerated exposure cycle of 1000 hours.

716.06 Measurement and Payment

716.06.1 Measurement - Unless otherwise indicated, measurement of protective painting or coating of concrete shall be by the metre square of developed surface areas covered by the protective painting.

716.06.2 Payment - Payment for protective painting of concrete shall be at the rate inserted in the Bill of Quantities, which rate shall include all labour, plant, materials, equipment and everything necessary for the proper execution of this work including surface preparation, emulsion and detergent.

Where protective painting of concrete is included in other items of work for which all inclusive items are prescribed in the Bill of Quantities, protective painting shall not be measured or paid for separately.

717 – PRESTRESSED CONCRETE WORKS *(NOT APPLICABLE)*

718 – BRIDGE BEARINGS AND BRIDGE EXPANSION JOINTS *(NOT APPLICABLE)*

719 – DRAINAGE OF BRIDGE STRUCTURES *(NOT APPLICABLE)*

720 – PILING WORK

720.01 General - Piling work shall be carried out as described in these Specifications and shall comply with the requirement indicated in the Drawings and as instructed by the Engineer.

Unless otherwise indicated, concrete and reinforcing steel bars shall be in accordance with these Specifications and as designated on the Drawings.

Piles shall be installed within the following maximum permitted tolerances:

Position	:	75 mm in either direction at finished level of pile head
Verticality	:	1 in 75 deviation from the vertical
Rate	:	1 in 25 deviation from the specified rate.

No method of forcible correction will be permitted.

The Contractor shall ensure that damage does not occur to completed piles or other structures through his method of working.

Piles shall be capable to provide the strength and loading requirements indicated on the Drawings.

All piling work shall be performed in accordance with approved codes and standards.

720.02 Submittals - The Contractor shall submit to the Engineer a programme of his proposed sequence and timing for piling work having regard to the avoidance of damage to adjacent properties, adjacent piles or unfilled pile excavations.

The Contractor shall also submit to the Engineer a fully detailed method statement. The method statement shall include details of equipment; materials; methods of quality control and testing; construction operations and sequence; and all other measures to be adopted by the Contractor for performing and satisfactorily completing the piling work.

Piling shall not commence until approval by the Engineer has been obtained.

720.03 Cast-in-place piles

- a. The Contractor shall carry out the work in accordance with the method statement which has been submitted to and approved by the Engineer.
- b. Drilling Fluid - When the use of drilling fluid has been approved by the Engineer for maintaining the stability of a boring, the level of the fluid in the boring shall be such as to achieve stability. An adequate temporary casing shall be used in conjunction with this method to ensure stability of the strata until concrete has been placed. The fluid shall be maintained at a level not less than one meter above the level of external groundwater.
- c. Bentonite as supplied by the Contractor and before mixing, shall comply with the British Engineering Equipment and Material Users Association, Drilling Fluid Materials, Publication No. 163, Bentonite, or equal approved. A certificate shall be submitted showing the properties of each consignment of Bentonite delivered.

Where the use of bentonite is approved it shall be mixed thoroughly with clean fresh water to make a suspension which will maintain the stability of the boring or excavation for the period necessary to place concrete and to complete construction.

- d. Pumping from a boring other than under controlled concrete placement shall not be permitted without the Engineer's approval.
- e. On completion of boring, all loose, disturbed or remoulded soil shall be removed from the bottom of the boring.

720.03.1 Driven Cast-in-place Piles

- a. Casings of driven cast-in-place piles shall be installed to the approved set or required depth and in the sequence of driving approved by the Engineer unless otherwise agreed.
- b. Each permanent casing of driven-cast-in-place piles shall be driven continuously unless otherwise agreed, until the approved set or required depth has been reached.
- c. The Contractor shall demonstrate that the final set obtained in driving the casing is maintained after a minimum period of 24 hours.
- d. Levels shall be taken immediately after the final set is obtained and before concreting each pile. When a pile has risen as a result of driving adjacent piles the Contractor shall submit to the Engineer his proposals for remedial work and shall carry out remedial work as agreed by the Engineer.

- e. Where a casing is to be made from a series of short sections it shall be designed and installed so as to produce a continuous watertight shaft. The dimensions and quality of the casing shall be adequate to withstand the stresses caused by handling and installation without damage or distortion.

720.03.2 Bored Cast-in-place Piles

- a. Where practicable, all pile excavation shall be inspected for their full length before concreting. The Contractor shall provide all the apparatus necessary for inspection.
- b. Excavations shall not be exposed to the atmosphere longer than is necessary and shall be covered at all times when work is not in progress. The Contractor shall take all precautions necessary to prevent the ingress of surface water or foreign matter.
- c. Temporary casing or drilling fluid shall be provided where necessary to ensure stability of the pile boring during boring, placing of reinforcement and concreting operations.
- d. Before concreting, any permanent casings shall be clean and undamaged.

720.04 Reinforcement

Reinforcement shall be as indicated on the Drawings and shall be maintained in its correct position during concreting of the pile. Where it is made up in cages, they shall be sufficiently rigid to enable them to be handled without damage. Measures shall be taken to ensure that the reinforcement is correctly placed and that concrete cover to reinforcement is not affected.

720.05 Concreting

- a. Immediately after the boring has been completed, the Engineer's approval to commence concreting shall be sought and when this has been obtained, concreting shall start and continue without interruption. All concrete shall be compacted to produce a dense homogeneous mass by an approved method. In a boring which contains water or drilling fluid the concrete shall be placed by tremie by an approved method.
- b. Temporary casings shall be extracted while the concrete within remains sufficiently workable to ensure that the concrete is not lifted or affected and the resultant pile is continuous and of full section.
- c. The top of the pile shall be brought above the required finished level of the pile head by an amount sufficient to ensure a sound pile and the surplus removed to ensure satisfactory bonding of the pile head to the structure.

720.06 Withdrawal of Casing

- a. When casings and linings are withdrawn as concreting proceeds, a sufficient head of concrete shall be maintained to prevent the entry of ground water or reduction of cross-section of the pile. No concrete shall be placed after the bottom of the casing or lining has been lifted above the top of the concrete.

720.07 Drilling Fluid and Soils Tests

- a. The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor to suit the approved method of construction. The frequency may be increased when necessary. Control tests for density shall be carried out daily on the drilling fluid using suitable apparatus.
- b. The Contractor shall take from the pile boring representative undisturbed soil sample at intervals agreed with the Engineer. Samples shall be tested by the Contractor to establish the physical characteristics and classification category of the samples.

720.08 Proof Loading of Piles

- a. **General** - Piles selected by the Engineer shall be tested by proof loading and the Contractor shall give the Engineer at least 24 hours notice before the commencement of tests. The test load shall be applied by a method agreed with the Engineer.
- b. **Trial Piles** - Trial piles shall be constructed and tested in advance of the main piling operations. Main piles shall not be constructed until the test results of the trial piles have been accepted and the Engineer has given his approval for the main piling operations to proceed.
- c. **Main Piles** - Main piles intended to form part of the permanent works shall be tested after the piles have attained the characteristic strength. Piles to be tested shall be selected by the Engineer for testing by one of the methods specified hereinafter. One of every ten piles shall be tested by proof loading. The test frequency shall be increased as determined by the Engineer if he considers that the quality of the work is suspect.
- d. Main piles shall not be used as reaction piles during proof loading tests without the approval of the Engineer.
- e. **Measuring Devices** - Load measuring devices shall be calibrated before and after each test, whenever adjustments or replacements are made to the devices and at the intervals recommended by the manufacturer of the equipment. Pressure gauges and hydraulic jacks shall be calibrated together. The Contractor's proposed methods of loading and measuring the movement of pile heads shall be submitted to the Engineer for agreement.

720.09 Methods of Pile Testing - Static pile load tests shall be carried out in accordance with ASTM D 1143 "Standard Test Method for Piles under Static Axial Compressive Load". Dynamic pile load tests shall be carried out in accordance with ASTM D 4945 "Standard Test Method for High Strain Dynamic Testing of Piles".

Total pile load tests shall constitute not less than 10% of the total number of piles. Out of the total number of test piles, only 10% are to be tested by Static Load Tests and the remaining shall be tested dynamically.

The selection of test piles and the method of testing to be adopted shall be as directed by the Engineer.

720.10 Pile Proof Loading Records - The Contractor shall submit to the Engineer a complete record of each pile test, including

- a. For maintained Load Test:
 - * A graph of load and movement plotted respectively above and below a common base line
 - * A graph of movement and recovery plotted vertically below a horizontal axis of load.
- b. For a Constant Rate of Penetration or Constant Rate of Uplift Test:
 - * The maximum load reached
 - * A graph of load against movement.

720.11 Reinstatement After Proof Load Tests

On completion of the testing of trial piles and main piles, pile caps and other temporary works shall be cut off and removed from the Site and the area reinstated to the satisfaction of the Engineer.

720.12 Pile Records

- a. A record of all piles installed shall be kept by the Contractor and a signed copy of the record of work done each day shall be submitted to the Engineer within 24 hours.
- b. The record shall include but not limited to the information listed below.
- c. On completion of piling, the Contractor shall deliver to the Engineer a schedule recording all relevant information and toe levels of all piles completed.
- d. The information to be included by the Contractor shall, as a minimum, contain the following:
 - * Diameter of each completed pile
 - * Toe level of each completed pile
 - * Details of temporary or permanent casing
 - * Type of boring and date of commencement and completion
 - * Details of soil strata encountered
 - * Details of soil samples and tests
 - * Ground water level
 - * Concrete mix details, class, strength at 28 days, slump and date of commencement and completion
 - * Volume of concrete placed in pile from site records
 - * Details of reinforcement, diameters, spacings, types and lengths actually placed.

720.13 Ultra-sonic Testing of Piles

- a. In addition to the pile proof loading tests, the Contractor shall carry out non-destructive ultra-sonic tests (P.I.T) for each completed pile intended to be incorporated in the permanent works.
- b. The ultra-sonic test equipment to be provided by the Contractor shall be suitable for the intended purpose and shall have a proven record demonstrating its successful use in pile testing. The equipment shall be properly calibrated and checked before and during testing operations and shall be used by fully qualified and experienced technicians.

720.14 Defective Works

Any defects in materials, workmanship or any deficiencies or imperfections in piling work shall be removed, replaced & made good by the Contractor to the satisfaction of the Engineer.

720.15 Measurement and Payment

720.15.1 Measurement - Measurement of piling work shall be by meter run of each type and diameter of permanent piles executed. The length of pile shall be defined as that length extending between the bottom level of foundations and the tip end of the pile. The level of the tip end of the pile shall be as indicated on drawings, unless subsurface conditions require the increase or shortening of pile length as approved by the Engineer.

720.15.2 Payment - Payment shall be at the rates shown in the Bill of Quantities which rates shall be full compensation for all materials, labour, equipment, installation, testing, concrete, reinforcement, boring, fluid, temporary or permanent casing and all other items or work required to execute and complete the piling work. No separate payment shall be made for steel or concrete extending beyond the theoretical levels indicated on Drawings at the top and tip ends of piles, except when the pile length is increased due to subsurface conditions, all as approved by the Engineer.

Temporary trial piles shall not be measured or paid for separately and the costs of which shall be deemed to be incidental to the permanent piling work and to have been included in full in the rates for permanent piles.

721 – STRUCTURAL REPAIR WORKS (*NOT APPLICABLE*)

722 – CHEMICAL ANCHOR DOWELS

722.01 General - Chemical anchor dowels shall be made at the locations indicated and/or approved by the Engineer.

722.02 Guidelines for the execution of chemical anchor dowels – A full method statement for the execution of chemical anchor dowels shall be proposed and submitted for the Engineer's review and approval.

Intended method statement should include, but without limitation, the following:

- Data sheet for materials to be incorporated in the works (resin/grout, dowel bars, etc.).

- Manufacturer's specifications and third party testing certificates confirming manufacturer's specifications.
- Manufacturer's recommended size/(diameter) and depth of grout hole, and length of embedment of dowel bars in the hole.
- Manufacturer's recommended procedure for the execution of chemical anchor dowels.
- Manufacturer's proposed quality control procedure and field testing.

722.03 Measurement and Payment Of Chemical Anchor Dowels

722.03.1 Measurement - Measurement of chemical anchor dowels shall be made by number for each type separately stating the bar diameter.

722.03.2 Payment - Payment for chemical anchor dowels shall be at the rate inserted in the Bill of quantities which rate shall include for drilling holes for the chemical anchors to required size/diameter and depth, cleaning, filling with approved grouting materials and embedding steel to required and approved length in the hole; rate shall also include for all labour, plant and materials and everything necessary for the proper execution of the work including drilling, cleaning, and resin, all in accordance with manufacturers recommendations and to the satisfaction of the Engineer.

723 – PEDESTRIAN FOOTBRIDGES (*NOT APPLICABLE*)

724 – CYCLOPEAN CONCRETE

724.01 General – Cyclopean concrete is a mixture of hard durable rock and of Portland cement concrete in accordance with these Specifications. It shall only be used at locations shown on drawings and/or where indicated and directed by the Engineer.

724.02 Requirements

724.02.1 Composition – Cyclopean concrete shall be produced to the following mix design:

- 40% in volume: hard durable rock of specific gravity of not less than 2.3 and a compressive strength higher than 300kg/cm² tested to ASTM D 2938.
- 60% in volume: concrete class B25 mixed, poured, tested, other in accordance with these Specifications.

724.03 Measurement and Payment of Cyclopean Concrete

724.03.1 Measurement – Measurement for Cyclopean concrete shall be as stated before in Sub-Clause "Measurement and Payment for Concrete".

724.03.2 Payment – Payment for Cyclopean concrete shall be as stated before in Sub-Clause "Measurement and Payment for Concrete".

725 – GROUND ANCHORS

725.01 General – Ground anchors are intended to maintain the stability of the slopes and/or to distribute and transmit the vertical pressure due to vertical bearing forces, all as shown on drawings and/or where indicated and directed by the Engineer.

725.02 Requirements

725.02.1 Composition – Ground anchors consist of anchor rods and cable in conformance with the criteria set on drawings.

725.03 Measurement and Payment for Ground Anchors Rods or Cables

725.03.1 Measurement – Measurement for Ground anchor rod or cable shall be in linear meter (meter run) along the length of the anchor penetrating the soil or rock strata.

725.03.2 Payment – Payment for ground anchor shall include the cost of supply of materials and installation of the rod or the cable including grouting, drilling of the anchor holes, the cost of materials and installation of the anchor head and others, and all necessary accessories and sundry activities to complete the Works.

726 – RIPRAP FOR BRIDGES

726.01 Description - This work consists of furnishing and placing riprap for bank protection, slope protection, drainage structures, and erosion control.

Riprap classes are designated as shown in Table 726-2.

726.02 Material

Conform to the following:

- Geotextile
- Cement grout
- Riprap rock

726.02.1 Geotextile. Use long-chain, synthetic polymers, composed at least 95 percent by mass of polyolefins or polyesters, to manufacture geotextile or the threads used to sew geotextile. Form the geotextile, including selvages, into a stable network such that the filaments or yarns retain their dimensional stability relative to each other.

Physical requirements: Conform to the table 726-1 for the type of geotextile specified.

All property values represent minimum average roll values in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the specified values).

Elevate and protect rolls with a waterproof cover if stored outdoors. When using a geotextile for a permanent installation, limit the geotextile exposure to ultraviolet radiation to less than 10 days.

Evaluation procedures: Furnish a commercial certification including the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile.

When samples are required, remove a 1m long, full-width sample from beyond the first outer wrap of the roll. Label the sample with the lot and batch number, date of sampling, project number, item number, manufacturer, and product name.

In addition, when geotextile joints are sewn, submit the seam assembly description and a sample of the sewn material. This description shall include the seam type, seam allowance, stitch type, sewing thread tex ticket number(s) and type(s), stitch density, and stitch gauge. If the production seams are sewn in both the machine and cross-machine directions, provide sample sewn seams that are oriented in both the machine and cross-machine directions. Furnish a sewn sample that has at least 2m of sewn seam and is at least 1.5m wide. Sew the sample seams with the same equipment and procedures that are used to sew the production seams. For seams sewn on-site, conform to the manufacturer's recommendations. Obtain approval of the seam before installation.

Table 726-1
Physical Requirements for Separation Geotextile

Property	Test Method ASTM	Units	Specifications ⁽¹⁾		
			Type II-A	Type II-B	Type II-C
Grab strength	D 4632	N	1400/900	1100/700	800/500
Sewn seam strength	D 4632	N	1260/810	990/630	720/450
Tear strength	D 4533	N	500/350	400 ⁽³⁾ /250	300/180
Puncture strength	D 4833	N	500/350	400/250	300/180
Burst strength	D 3786	kPa	3500/1700	2700/1300	2100/950
Permittivity	D 4491	s ⁻¹	0.02	0.02	0.02
Apparent opening size	D 4751	mm	0.60 ⁽²⁾	0.60 ⁽²⁾	0.60 ⁽²⁾
Ultraviolet stability	D 4355	%	50% after 500 hours of exposure		

726.02.2 Cement Grout. Furnish 1 part hydraulic cement and 3 parts sand. Thoroughly mix with water to produce a thick, creamy consistency.

726.02.3 Riprap Rock. Furnish hard, durable, angular rock that is resistant to weathering and water action and free of organic or other unsuitable material. Do not use shale, rock with shale seams, or other fissile or fissured rock that may break into smaller pieces in the process of handling and placing. Conform to the following:

- (a) Apparent specific gravity, AASHTO T 85 2.50 min.
- (b) Absorption, AASHTO T 85 4.2% max.

- (c) Coarse durability index, AASHTO T 210 50 min.
(d) Gradation for the class specified Table 726-1

(1) The first values in a column apply to geotextiles that break at < 50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50 percent elongation (ASTM D 4632).

(2) Maximum average roll value.

(3) The minimum average tear strength for woven monofilament geotextile is 245 N.

Table 726-2
Gradation Requirements for Riprap

Class	Percent of Rock by Mass	Mass (kg)	Approximate Cubic Dimension⁽²⁾⁽³⁾ (mm)
1	20	10 to 15	150 to 200
	30	5 to 10	125 to 150
	40	0.5 to 5	50 to 125
	10 ⁽¹⁾	0 to 0.5	0 to 50
2	20	25 to 50	200 to 250
	30	10 to 25	150 to 200
	40	1 to 10	75 to 150
	10 ⁽¹⁾	0 to 1	0 to 75
3	20	100 to 150	350 to 400
	30	50 to 100	250 to 350
	40	5 to 50	125 to 250
	10 ⁽¹⁾	0 to 5	0 to 125
4	20	250 to 350	450 to 500
	30	100 to 250	350 to 450
	40	10 to 100	150 to 350
	10 ⁽¹⁾	0 to 10	0 to 150
5	20	700 to 1000	650 to 700
	30	350 to 700	500 to 650
	40	25 to 350	200 to 500
	10 ⁽¹⁾	0 to 25	0 to 200
6	20	850 to 1600	700 to 850
	30	500 to 850	550 to 700
	40	50 to 500	250 to 550
	10 ⁽¹⁾	0 to 50	0 to 250

-
- (1) Furnish spalls and rock fragments graded to provide a stable dense mass.
 - (2) The volume of a rock with these cubic dimensions has a mass approximately equal to the specified rock mass.
 - (3) Furnish rock with breadth and thickness at least one-third its length.

726.03 Construction Requirements

726.03.1 General - Dress the slope to produce a smooth surface.

726.03.2 Placed Riprap

Placed riprap is rock placed on a prepared surface to form a well-graded mass.

Place riprap to its full thickness in one operation to avoid displacing the underlying material. Do not place riprap material by methods that cause segregation or damage to the prepared surface. Place or rearrange individual rocks by mechanical or hand methods to obtain a dense uniform blanket with a reasonably smooth surface.

726.03.3 Keyed Riprap

Keyed riprap is rock placed on a prepared surface and set into place by impact pressure.

Set the riprap into place by exerting impact pressure with a hydraulic-powered bucket or an approximate 2000 kg flat-faced mass. Repeated impacts should be made until the rock is firmly seated and forms a reasonably uniform surface without reducing the effective sizes of the rocks. Do not use impact pressure on riprap below the water surface.

726.03.4 Grouted Riprap

Grouted riprap is rock placed or keyed on a prepared surface with the voids filled with grout.

Place rock for grouted riprap according to Subsections B or C. Thoroughly moisten the rocks and wash excess fines from the riprap or to the underside of the riprap. Place grout only when the air temperature is no less than 1°C within the near-surface voids of the riprap. Place the grout in a manner to prevent segregation. Begin placing grout at the lowest elevation of the riprap. Fill all voids without unseating the rocks. Do not exceed 1.5 m thickness for each layer of grouted riprap. Allow 3 days curing time before adding the next layer of riprap and grout. Provide weep holes through the grouted riprap as required. Keep the grouted riprap moist for 3 days after the work is completed and protect it from freezing for a minimum of 7 days after grouting.

726.03.5 Acceptance

See Table 726-3 for sampling and testing requirements.

Table 726-3
Sampling and Testing Requirements

Material or Product	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Riprap (705.02)	Apparent specific gravity & absorption	—	AASHTO T 85	1 per material type	Source of material	Yes	Before using in work
	Coarse durability index	—	AASHTO T 210	"	"	"	"
	Sodium sulfate soundness	—	AASHTO T 104	"	"	"	"
	LA abrasion	—	AASHTO T 96	"	"	"	"
Mortar	Making test specimens Compressive strength	—	AASHTO T 23 & T 22	1 per mix design	—	Yes, when requested	Before using in work

726.04 Measurement And Payment

726.04.1 – Measurement - Measure riprap by the cubic meter in place.

726.04.2 – Payment - The accepted quantities will be paid at the contract price per unit of measurement listed in the bill of quantities. Payment will be full compensation for the work prescribed in this Section.

727 – RUBBLE MASONRY WORK

727.01 General - This work consists of furnishing rubble masonry at the locations indicated on the Drawings and directed by the Engineer.

1. The work shall comply with the typical details indicated on the drawings and shall include plain concrete, mortar bedding and stone embedded in mortar together with edge curbs.
2. Plain concrete mortar and edge curbs shall conform to the dimensions and class shown on the Drawings.
3. Stone shall be hard and durable, of uniform colour and texture and obtained from approved quarries. Stone pieces shall have a thickness of between 80 and 120 mm and plan dimensions between 150 mm and 300 mm.
4. The Contractor shall submit to the Engineer for approval representative samples of the stone proposed to be used for rubble masonry construction.
5. Trial panel shall be prepared by the Contractor. The dimension of the trial panel shall not be less than 2 m². No work shall be commenced prior to approval by the Engineer of the trial panel.
6. Plain concrete shall be placed on compacted subgrade to provide a uniform working surface. Mortar shall then be applied onto the plain concrete starting at the low side and systematically working upwards. Stones shall be neatly placed and tamped into the mortar such that approximately one half of the depth of the stone is embedded into the mortar. The finished surface shall be uniform and free from any loose materials or stones. The mortar shall be kept moist for not less than 3 days after its final set.

Any defects shall be replaced or made good in a manner acceptable to the Engineer.

727.02 Measurement and Payment

727.02.1 Measurement - Rubble masonry work shall be measured by the meter square of the constructed rubble masonry. Measurement shall include the edge curbs.

727.02.2 Payment - Payment shall be at the rate indicated in the Bill of Quantities which rate shall include all materials, labour, equipment, earthwork, edge curbs and all other items and work necessary to complete the works.

728 BLOCKWORK

728.01 SCOPE OF WORK

The Contractor shall furnish all necessary materials and construct all blockwork required under this Contract as indicated on the Drawings and as herein specified.

728.02 MATERIALS

Cement and water shall be as described in "Concrete Work". Lime shall be hydrated lime complying with BS EN 459-1:2010 Class B to be soaked in water for not less than 16 hours before use.

Sand shall be clean and sharp, free from salt, loam and organic matter. It shall comply with BS EN 13139:2002 as appropriate.

728.03 CONCRETE BLOCKS

Generally blocks shall be of an approved local manufacture made with cement and sand in approved vibrated pressure machines. The sand to be used for blocks shall be chemically and structurally stable and shall comply with the Table of Gradings given hereunder:

TABLE OF GRADINGS - Percentage Passing		
B.S. Test Sieve No.	SIZES mm or microns	Sand for Blocks
-	4.76	95 - 100
7	2.40	70 - 95
14	1.20	45 - 85
25	600	25 - 60
52	300	5 - 30
100	150	0 - 10

NOTE: The Above figures represent the limits of percentage (by weight) passing sieves of the sizes mentioned.

The following mixing table shall be strictly adhered to in all cases:

MIXING TABLE		
Nominal Mix	Cement, Kg	Sand, m ³
1:5	300	1.00

Blocks shall be hard, sound, square and clean with sharp, well defined arises and shall be 20 cm in height.

The design of the cavities and webs of hollow blocks shall be submitted to the Engineer for approval before manufacture. The thickness of the membranes or solid portions of the hollow blocks shall be not less than 2.5 cm each in the case of 10cm wide blocks and 4 cm each in the case of blocks 15 cm wide and over and the combined thickness of the solid portions shall exceed one third of the total thickness in either horizontal direction.

Immediately after moulding, the blocks shall be placed on clean, level, timber pallets. Blocks shall not be removed from the pallets until inspected and approved by the Engineer. Blocks shall be cured by being kept thoroughly wet by water sprinklers or other approved means for a period to be determined by the Engineer but in all cases for not less than 3 days. Blocks must not be left on earth in honeycomb fashion. Solid stacking will not be permitted. All blocks shall be at least one month old before use.

Blocks shall be tested for compressive strength whenever required by the Engineer. Blocks shall have an average compressive strength of 40 Kg/cm². Should any blocks prove to be below this strength then all of the blocks from the same batch may be rejected.

728.04 MORTAR

Mortar for blockwork shall consist of 1 part cement to 3 parts of sand by volume. For work not in contact with earth or sand, one quarter lime by volume may be added to the mix.

Should the Contractor wish to use a plasticiser with mortar, then the mortar shall consist of 1 part cement to 4 parts sand with plasticiser added and used strictly in accordance with the manufacturer's instructions. The plasticiser must be approved by the Engineer before use.

Mixing shall be carried out by means of an approved mechanical batch mixer. The mortar shall be mixed dry until a uniform mix is obtained. Sufficient water shall then be added and the mixing continued until a homogeneous mix is obtained. Excess water shall not be used in the mix.

In the case of cement-lime mortar, the sand and lime shall be mixed first and cement added. It shall be assumed that the lime has not increased the bulk of the sand.

All mortar shall be used before the initial set has taken place and on no account shall mortar which has commenced to set be remixed with water or new batches and used.

728.05 WORKMANSHIP

All blockwork shall be set out and built to the respective dimensions, thickness and heights, shown on the drawings and/or as instructed in writing by the Engineer.

Unless otherwise detailed on drawings, hollow blocks shall be used for blockwork walls. All closures, end blocks such as at door jambs, window openings, etc. shall be solid. The blocks shall be well soaked before being used and the tops of walls left off shall be wetted before work is recommenced.

Blocks shall be laid in true and regular courses on a full bed of mortar of 1 cm average thickness, exclusive of any key in the jointing surfaces of the blocks. Sufficient mortar shall be used in bedding and jointing to ensure that all keys are solidly filled.

All horizontal joints shall be properly level. The vertical joints shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds. All walls shall be plumbed vertical.

Standard sized blocks shall be used wherever possible. Broken blocks shall not be used except where required for bonding purposes. Walls and partitions shall be bonded to one another at angles and junctions.

Joints on faces of block walls which are to be rendered or plastered shall be raked out for a depth of 1 cm as the work proceeds.

Walls shall be carried up regularly without leaving any part more than one meter lower than another unless the permission of the Engineer is first obtained. Work which is left at different levels shall be raked back.

Blockwork built against concrete columns shall be bonded by means of horizontal strips of galvanized expanded metal lathing 8 cm wide cast into concrete and left protruding for building into horizontal joints of blockwork at every third course and /or by means of galvanized mild steel cramps 30mm wide x 3mm thick x 200mm girth "gun-shot" fixed to concrete columns at one end with the other end split and built into joints of blockwork.

The Contractor shall cut and fit blockwork as required, leave or form chases for edges of concrete slabs, steps, ends of partitions, etc. cut chases for pipes, conduits, etc. and generally perform all cutting away for all trades.

728.06 Measurement and Payment

728.06.1 Measurement - Masonry work shall be measured by the meter square of the constructed masonry wall.

728.06.2 Payment - Payment shall be at the rate indicated in the Bill of Quantities which rate shall include all materials, labour, equipment, earthwork, edge curbs and all other items and work necessary to complete the works.

**** END OF SECTION ****

SECTION – VIII
STRUCTURAL STEELWORK

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SECTION – VIII

STRUCTURAL STEELWORK

800 – GENERAL

800.01 Description of Work - The Structural Steelwork comprises the design of structural steel works, connections and foundations if required, supply of materials, fabrication, surface preparation, painting, delivery to site, unloading and storage on site and erection together with all bolts and assemblies including templates where necessary, shop and site welds, lifting tackle, temporary bracing and cleats, packs, wedges, special scaffolding, surveying tackle, labor and other equipment necessary for the careful and accurate completion of the Structural Steelwork as shown on the drawings and to the satisfaction of the Engineer.

800.02 Quality Assurance

800.02.01 Codes and Standards - Comply with the applicable requirements of the following codes and standards:

CP British Standard Codes of Practice:

3 Chapter V, Loading, Parts 1 & 2.

BS British Standards

4 Structural Steel Sections

12 Specification for Portland Cement.

449 The Use of Structural Steel in Building.

639 Covered Electrodes for the Manual-Arc Welding of Mild Steel.

729 Hot Dip Galvanised Coatings on Iron and Steel Articles.

812 Testing Aggregates.

1199 Specification for Building Sands from

1200 Natural Sources.

1449 Steel Plate, Sheet and Strip (all Parts).

4190 ISO Metric Black Hexagon Bolts, Screws and Nuts.

4232 Surface Finish of Blast-Cleaned Steel For Painting.

4320 Metal Washers for General Engineering Purposes, Metric Scale.

4360 Weldable Structural Steels.

4395 High Strength Friction Grip Bolts and Associated Nuts and Washers for Structural Engineering. Metric Series.

4606 The Use of High Strength Friction Grip Bolts in Structural Steelwork. Metric Series.

4848 Hot-Rolled Structural Steel Sections.

4870 Approval Testing of Welding Procedures.

4871 Approval Testing of Welders Working to Approved Welding Procedures.

4872 Part 1:1982, Fusion Welding of Steel.

5135 Metal-Arc Welding of Carbon and Carbon Manganese Steel.

5400	Steel Concrete and Composite Bridges Part 2: 1985, Specification for Loads Part 4: Code of Practice for Design of Concrete Bridges Part 5: Code of Practice for Design of Composite Bridges Part 6: Specifications for Materials and Workmanship, Steel Part 9: Bridge Bearings
5950	Structural Use of Steel Work in Building. Part 8: 1990, Code of Practice for Fire Resistant Design.
7079	Preparation of Steel Substrates Before Application of Paints and Related Products. (Including any applicable parts for a specific requirement).

AASHTO Standard Specifications for Highway Bridges

UBC Uniform Building Code

800.02.02 Quality Control

- a. Materials and fabrication procedures shall be subjected to inspection and tests in the mill, shop and field. Such inspections and tests shall not relieve the Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.
- b. Promptly remove and replace materials or fabricated components which do not comply.

800.02.03 Design of Members and Connections - All details shown are typical; similar details apply to similar conditions, unless otherwise indicated. Verify dimensions at the site whenever possible without causing delay in the work.

800.03 Design Criteria

- Design shall be carried out in accordance with the AASHTO Standard Specifications, 2001 Edition for Structural Supports for Highway Signs, Luminaries and Traffic Signals as amended by the 2002 interim and the AASHTO Standard Specifications for Highway Bridges or internationally recognized equivalent.
- Minimum vertical clearance for overhead sign support structures shall be 5.50 meters.
- Design wind velocity shall be 150 kilometers per hour. Gantry shall be designed for wind load acting horizontally as per IBC code, 2009.
- In addition to strength design, all members and fasteners shall be designed so that the maximum stress does not exceed the allowable fatigue stress range as given in Table 10.3.1A for over 2000000 cycles. Fatigue limit for details on tubular connections is given in AWS D1.1 Structural Welding Code.
- Overhead sign structure connections shall be designed/ detailed for fatigue category III or better.

- A minimum design life of 50 years is required.
- The gantry shall be designed for an additional load of 50 Kilogram and 2.0 m² of wind area for future installation.
- Deflection criteria: Maximum vertical deflection shall be limited to 1/480 of the span length. Maximum horizontal deflection shall be limited to 2.5% of gantry height.
- Foundation shall be placed on undisturbed soil with top of foundation a minimum of 600mm below FGL. Height shall be of a minimum of 500 mm
- Height of walkway parapet shall be of a minimum of 1000mm.

800.04 Submittals - The Contractor shall submit to the Engineer for approval the following:

- Product data which shall fully detail all materials, products, manufacture, installation, quality control, tests and applicable codes and standards.
- Shop fabrication drawings with supporting engineering calculations for all structural steel elements and supporting structures and foundations and layout.

The Contractor shall submit to the Engineer for approval prior to the fabrication of the steelwork two copies of each fully detailed and dimensioned shop fabrication drawings including setting out details showing the location and size of all bearings, holding down bolts, drillings and other fixings whether for his use or for later use by others. Where called for, calculations for connections shall be included with these details. It is intended that shop connections are to be bolted with 8.8 grade bolts to BS H.S.F.G and to the approval of the Engineer.

- Layouts indicating the location, levels, and other details of erection, support, and foundations of all steel structures.

Approval of detailed drawings shall not in any way relieve the Contractor of his responsibility for any error subsequently discovered in his work.

801 – PRODUCTS

801.01 Materials - All concrete structural elements shall be designed to a minimum cylinder compressive strength of 28 N/mm² at 28 days and shall comply with BS 5400.

All steel sections, bolts and fittings shall comply with the appropriate BS for steel quality as specified on the drawings, profile and or manufacture.

The Contractor shall refer to the appropriate sections of the Specifications for other materials involved in the design/construction of the steel structures.

The Contractor shall obtain and submit to the Engineer for approval copies of all certificates for the actual steel sections being supplied. The Engineer may call for samples of any steelwork to be submitted for an independent laboratory analysis test.

Unless otherwise noted all rolled steel sections are to be supplied in mild steel grade S275 to BS EN 10025 but the grade designated modified to provide an equivalent permissible stress level according to metal thickness and welding requirements of so involved.

The steel grade for hot rolled hollow sections is to be S275 to BS EN 10025 with similar provisions obtaining.

Steel elements shall be parallel and straight to ± 10 mm but the tolerance on the gauge shall override these requirements in cases where the gauge would otherwise be out of tolerance. Beams shall be true in section, free from twist and if more than one beam is used in the same run, all beams are to be from the same rolling unless specifically authorized otherwise.

The Contractor may subject to the Engineer's written approval supply steel section to an alternative National Standard other than BS and in these circumstances certificates of origin and compliance with the local standard will be required together with mill test certificates. The Contractor in these circumstances will not be permitted to use a section of lower strength of stiffness to that for the section specified on the drawings.

801.02 Workmanship General - All steel work including connections shall be designed and fabricated in accordance with the appropriate BS to the tolerance specified using BS 5400.

All holes shall be drilled to the appropriate size for types and diameter of bolt being used, for H.S.F.G. bolts the clearance shall not exceed 2mm excepting where approval is given for the adoption of oversize holes required for tolerance reasons and in this case special oversized washers will be supplied. No punched holes will be allowed.

All bolts shall have steel washers between the nut and the number being fixed. The head and/or nut of all bolts shall have taper washers as necessary to give a bearing without bolt distortion. Load indicating washers shall only be used in locations permitted by the Engineer and when used shall bear against a hardened steel washer or the head of the bolt.

Site connections will be formed with H.S.F.G or bolts to the appropriate BS of such size and quality to carry the loads specified on the drawings unless specified otherwise.

Bolts will be to BS 4190 set in 2mm clearance holes. Alternatively H.S.F.G. bolts will be supplied to BS 4395 and shall be installed to the requirements of BS 3294 respectively with holes drilled to a clearance not exceeding 2mm (except as otherwise directed). Faying surfaces for these connections are generally to be as required BS 4604 except as directed otherwise.

All bolts shall show at least two turns of complete threads beyond the nut face and shall be fitted with the correct flat or tapered washer required.

The threaded portion of any connecting bolt other than H.S.F.G. bolts shall terminate clear of any shear plane to ensure the full value of the shank is developed in resisting shearing effects on the connection concerned.

Stud welding of fixings (other than composite action studs on beams) and shot fired fastenings will not be allowed unless authorized in writing by the Engineer subsequent to satisfactory performance tests and trials.

Contact faces between members which are to be formed with H.S.F.G. bolts shall be cleaned and treated as directed by the Engineer and after fabrication the surfaces protected until time of assembly. Contact faces between normally bolted connections are to be cleaned and protected locally with red lead paint or other approved means prior to final erection and subsequent protection.

801.03 Welding - All welding at works (and, if permitted in writing, on site) shall be carried out in accordance with BS requirements. All welding operatives employed shall be tested and qualified welders in accordance with BS recommendations and the Contractor shall submit to the Engineer when required evidence of qualification. Additional testing by an independent inspection company (see 801.04 below) will also be implemented to verify the operative standard.

All weld connections shall be accurately made and the point faces formed in accordance with BS for metal type and thickness as appropriate and any necessary pre-treatment due to metal thickness or type shall be undertaken. All welding electrodes shall be of the appropriate type to be compatible with the metal being welded.

801.04 Welding Inspection - The Contractor will employ to act on behalf of the Engineer an independent inspection company to carry out regular inspections and non-destructive tests which will include for ultra-sonic tests, dye penetration tests and visual examinations, whilst the fabrication and erection are in progress to ensure compliance with the specification and BS requirements and an adequate standard of workmanship and supervision for the works. The Contractor is to allow unrestricted access to facilities at his works or on site for authorized personnel to carry out inspection procedures on behalf of the Engineer in respect of the fabrication, erection and welding of the steelwork in the contract. The Contractor is also to include for the cost of testing welding operatives to verify their standard as in Clause 801.03.

The independent weld inspection company to be employed will be subject to their status being established to the satisfaction of the Engineer. Any such company shall operate and conform fully to the provision of ASTM E 329. Similar conditions are to obtain if site welding is permitted.

In addition to inspection for welding purposes the Engineer shall be entitled at all reasonable times during the fabrication work to inspect, examine and if required call for tests on the Contractor's premises of the materials and workmanship of all elements to be supplied under the contract and if part of the said elements are being fabricated on other premises to inspect, examine and if required test as if the said elements were being manufactured on the Contractor's premises. Such inspection, examination or testing if made shall not release the Contractor from any obligation under the Contract.

Inspection duties may also be delegated by the Engineer to the same company as called for above and the Contractor shall make due allowance for covering costs so involved.

The Contractor shall give the Engineer reasonable notice in writing of the date and the place at which elements will be ready for inspection and examination and/or testing as provided on the Contract so that the Engineer can attend at the place so named if required.

Where the contract provides for tests on the premise of the Contractor or of any Sub-contractor the Contractor shall provide such assistance, labor, materials, electricity, fuel, stores, apparatus and instruments as may be requisite and as may be reasonably demanded to carry out such inspections and tests efficiently.

801.05 Delivery - No element of the Contractor's work shall be shipped or delivered to the site and until an intimation in writing has been applied for and obtained by the Contractor from the Engineer that the element has been fabricated to the correct standards.

The Contractor shall also provide during these inspections all materials and equipment necessary to enable the Engineer's representative to check and establish the level of surface cleaning and dry film thickness of priming paint coats applied prior and subsequent to fabrication.

All sections are to be fully marked and all attachments and fittings securely attached thereto to prevent loss or misplacement.. All elements are to be supplied in a manner that will prevent loss and damage due to mishandling of the fabricated sections and fittings during transportation and loading or unloading at any point.

801.06 Connections - In all times the Contractor shall design and supply connections to withstand the load, forces and bending moments. The design and details of all connections shall be the responsibility of the Contractor and shall be in accordance with the relevant sections of BS 449, BS 5400 and BS 5135 as applicable.

The Contractor shall submit detailed calculations for all connections for approval by the Engineer.

801.07 Protection General - The Contractor will be responsible for the whole surface preparation of steelwork and the protective system. The materials and workmanship generally is to be in accordance with the recommendations of BS 5493.

801.08 Cleaning - All steelwork whether cased or painted is to be cleaned by shot blasting to the same standard as set out in BS 7079.

Prior to shot blasting all steel is to be degreased and cleaned of any foreign material for effective shot blasting and subsequent painting.

After preliminary treatment as above all steelwork is to be shot blasted so as to achieve a surface finish standard equal to that described as Second Quality Finish in BS 7079 or alternatively SA 2.5 as designated in the Swedish Standard SIS 055900, three such coupons are to be provided.

Shot blasting will normally be carried out prior to fabrication and the Engineer's written permission will be required if it is proposed to shot blast after fabrication.

801.09 Painting Exterior Members - As soon as possible after shot blasting but not longer than four hours, an approved zinc rich epoxy barrier primer is to be applied to all steelwork, to table 4H Part 2, BS 5493.

The barrier primer coat shall have a minimum dry film thickness of 75 microns and shall be followed with one undercoat and one top coat each of minimum dry film thickness of 100 microns using an approved two-pack chemical resistant epoxy paint all to BS 5493 type Group K.

The completed paint system shall be equal to, or better, than the requirements under reference SK3 of BS 5493.

Painting will only be allowed to take place when the combination of temperature (air and steel) and humidity meets the satisfaction of the Engineer and paint manufacturer.

801.10 Ten Year Guarantee - The entire steelwork painting system shall be guaranteed against any failure or need for maintenance, for 10 years. The guarantee format will have to be submitted to the Engineer prior to execution, for approval.

802 – STRUCTURAL STEELWORK ERECTION

802.01 Setting Out - The Contractor shall be responsible for accurately checking all setting out of the Works to the specified positions, dimensions, and level accuracy and reporting any discrepancies before erection commences. Any errors in position, level, dimension or alignment of any part of the Works at any time shall be rectified by the Contractor at his own expense. The Contractor shall provide the Engineer with all facilities, equipment and labour to enable him to check the setting out and levels of the Works at all times. The checking of any setting out point, line or level by the Engineer shall not in any way relieve the Contractor of his responsibility. All setting out points shall be clearly marked and protected from damage or disturbance during the execution of the Works.

802.02 Erection - Structural steelwork is to be set on foundations and erected in such manner so as not to distort or overstress any part or connection due to the erection activities. Steel wedges and solid packs and shims shall be used to level up bases. The Contractor's attention is drawn to the manner in which holding down bolts provide stability only after the grouting up process has been carried out and special provision must be made therefore by the Contractor to provide stability to the unfinished framework at all times during and after erection right up to the time that the structure is independently stable. Safety and stability in these intermediate phases prior to completion shall be considered and the provisions given in BS 5531 adhered to. The provisions of BS 5400 covering erection shall also be followed. Details of the bracings proposed to provide stability are to be provided by the Contractor within fourteen days of his being appointed.

802.03 Supervision of Erection Work - The whole of the erection is to be carried out under the direct control of a fully qualified and experienced erection supervisor who shall be directly responsible to the Contractor's management. The erection supervisor will also have a

senior erection foreman who will be in charge of all day to day erection work as this progresses on site, who shall be responsible for not more than four gangs each of skilled and experienced steelwork erectors, each gang with its own sub-foreman in charge.

802.04 Erection Equipment - The Contractor is to provide all the cranes, hoists, generators, compressors or any other mechanical equipment necessary for his erection work including any pneumatic tools and all small hand tools.

This equipment shall be maintained in a safe and satisfactory condition throughout the time erection work progresses and an inventory of such equipment shall be maintained at all times, recording quality, quantity, capacity at all times.

When crane and hoists are used the provision of BS CP 3010 are to be adhered to at all times.

Where ladders and scaffolds are required for access to connections, these shall be provided by the Contractor and shall be safe and secure and rigidly fixed, rope ladders will not be allowed.

802.05 Inspection of Erected Steelwork - All main connections and any connections formed with H.S.F.G. bolts will require inspection and checks by the Engineer and the Contractor shall provide all necessary ladders, scaffolds, or other suitable access for this purpose.

When H.S.F.G. bolts are used the method of identifying fully tightened connections (e.g. agreed colour spot of paint) shall be determined prior to the erection of steelwork. Connections shall be subject to 10% random inspection and if any are defective then a further 10% shall be checked; if any of these are defective then the steel erectors shall check all connections again, after which the inspection procedure shall be repeated but on 20% of the connections.

The Contractor shall be responsible for the immediate replacement and making good at his own expense of all connections rejected at the inspections and for the removal from site of all the bolts, nuts, etc., concerned. The Contractor should ensure that the steel erectors are available on site until satisfactory completion of the aforementioned inspections.

802.06 H.S.F.G Bolts - These shall be used only if permitted by the Engineer. The equipment to be used and method of tightening is to be submitted for approval as well as the bolt locations proposed.

When installing bolts, additional lubrication shall be used with the Engineer's approval to ease the tightening of bolt assemblies. The Contractor shall ensure that no lubricant gets between plates and plies of the steelwork; final tightening of bolt assemblies shall be done in staggered pattern and where there are more than four bolts in a joint, they shall be tightened from the center of the joint outwards.

802.07 Surface Finish to Steelwork - Prior to delivery to site, all the structural steelwork shall be painted with the approved paint system to the required d.f.t. The painting shall be carried out in the fabrication yard in a suitable clean and shaded area. Any defective work shall be repaired prior to delivery to site. Any damage to the paint finish that occurs due to handling, transportation or erection shall be made good by the Contractor.

In addition all site bolted or welded joints shall, after erection, be painted as the remainder of the steelwork. If permission is given for the use of load indicating washers with H.S.F.G. bolts, particular care is to be taken to fill and seal the gap between the washer and the fittings created by the indicating nibs.

Any steelwork to be cased is also to be left in a clean condition with not loose rust or flaking paint so that only a light surface treatment is required prior to concrete pouring to achieve satisfactory cased steel/concrete construction.

802.08 Grouting of Stanchions - When the steelwork area in question has been satisfactorily erected, lined, leveled and plumbed the stanchion base plates and H.D. bolt pockets (or sleeves, if used) are to be filled with a shrinkage compensated grout material which will provide shear strength not less than that of the concrete base upon which the stanchion is supported and with a minimum 28-day cube strength of 40N/mm^2 . The shrinkage compensated grout shall be shuttered, poured, protected and cured as directed thereby. Samples of the grout, in the form of test cubes, etc., are to be taken as directed by the Engineer for testing to ascertain the properties of the material.

The provision of the recommendations given by A.C.I. committee 223 'Recommended Practice for the Use of Shrinkage Compensated Concrete' published in A.C.I. Standard 223.77 are also to be followed except where in direct variance with the manufacturer's instructions in which instances the Contractor shall report the matter of the Engineer for his direction.

802.09 Clearing Up - Subsequent to the completion of erection work, the Contractor shall allow for clearing up the site of his work with the removal of all unwanted equipment and materials.

Any temporary braces, straining wires or other items provided for stability during erection prior to the frame being stable be removed and marks or damaged areas made good as required.

802.10 Measurement and Payment

802.10.1 Measurement - Measurement shall be made by the number of structures to be constructed.

802.10.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include but not limited to design of structure, structural steel, and other items as applicable to the particular structure, including, bridge deck, parapet, approach structures, support structures, connections, expansion joints, bearings, foundations, blinding, earthworks (excavation and backfilling), painting, corrosion protection, fixings, and all other materials, labour, equipment and other items and work necessary to complete the works to the satisfaction of the Engineer.

**** END OF SECTION ****

SECTION – IX

POTABLE WATER, STORMWATER AND SEWERAGE NETWORKS

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SECTION – IX

POTABLE WATER, STORMWATER AND SEWERAGE NETWORKS

900 – GENERAL

900.01 Scope of Work

The work consists of the supply, installation and testing sanitary sewer, stormwater and potable water pipelines and fittings with associated manholes, boxes, valves, and meters, as indicated on the Drawings and as herein-under specified and according to the instructions in writing of the Engineer.

Prior to shipment from factory, pipes shall be tested at the place of manufacture and the Contractor shall submit to the Engineer for each consignment or shipment an authenticated certificate to indicate that the pipes and fittings have been tested by the manufacturer and found to comply with these specifications.

900.02 Related Codes and Standards

- British Standards (B.S.)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- American Water Works Association (AWWA)

900.03 Quality Assurance

Manufacturers shall be firms regularly engaged in the manufacture of specified items whose products have been in satisfactory use, in similar service for not less than 10 years.

900.04 Submittals

The Contractor shall submit to the Engineer for approval the following:

- detailed product data together with the manufacturer's or supplier's names, technical and performance data, applicable codes and standards and test certificates.
- construction details and drawings for all elements of the work, interconnections and associated work, indicating locations, levels and other characteristics together with method statements for execution of the works.

No materials shall be ordered nor work commenced on the Site before approval by the Engineer of the Contractor's submittals pertaining to such materials and work. Execution of the work shall be in accordance with approved submittals.

901 – EARTHWORKS FOR POTABLE WATER, STORMWATER & SEWERAGE NETWORKS

901.01 General

The Contractor shall carry out all the necessary excavations for trenches and structures such as manholes, inspection chambers, etc. for potable water, stormwater, and sewerage 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.

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.

Excavations shall be carried out to the dimensions shown on the drawings and in such manner as will give suitable room for building the structures or laying and joining the pipework.

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.

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.

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.

901.02 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

901.03 Excavation in Restricted Areas

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.

901.04 Methods of Detection of Existing Utilities

901.04.1 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 availability of existing utilities.

901.04.2 Trial Excavation - 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 sketch showing the proposed location of all trial excavation to the Engineer. The prior approval of the Engineer shall be obtained for such excavations.

Unless otherwise approved, trial excavations shall be carried out by hand and in a manner to ensure that damage to existing utilities are avoided. The Contractor shall submit to the Engineer for his approval a written report and sketch 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.

901.05 Sheet piling and Bracing

The Contractor shall furnish, put in place and maintain such sheet piling, 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 put in at the expense of the Contractor.

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 sheet piling and shoring, sheet piling etc. and all other pertinent details relating to pipe laying and/or construction of structures.

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.

The Contractor shall leave in place to be embedded in the backfill, or concrete, all sheeting, bracing, etc., which is indicated on 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.

All sheeting and bracing not to be left in place shall be carefully removed in stages as described below and in such a 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. The contractor is not allowed to withdraw or lift the sheet piling in a single stage following termination of pipe-laying and backfilling of trenches. Sheet piling shall be removed (withdrawn or lifted) vertically in stages of 25cm to allow for the compaction of soil in layers of the specified thickness.

901.06 Stockpiling of Excavated Material

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.

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

901.07 Excavation in Poor Soil

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.

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.

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.

901.08 Keeping Excavations Free from Water

901.08.1 General - 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.

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.

901.08.2 Temporary Subdrains - 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.

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.

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.

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.

901.08.3 Dewatering System - 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.

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

901.08.4 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.

901.09 Excavation in Rock

901.09.1 General - 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 0.5m³ 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.

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. Such logging shall be incorporated in the measurement of percentages and quantities of rock out of excavated soil as extra over other soil excavations.

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.

Under all circumstances, materials with a compressive strength of 60kg/cm² tested on a 24 hour soaked rock core to ASTM D2938 (or similar approved standard) shall not be counted as rock.

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,

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.

901.09.2 Rock Blasting - 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.

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.

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.

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.

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.

901.10 Excavation for Trenches

901.10.1 General - 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 on the Drawings and/or as directed by the Engineer.

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. 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.

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.

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.

901.10.2 Depth of Trench - 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.

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.

Where rock excavation is encountered, the trench shall be excavated to such extra depth as is called for under Clause 901.09.

901.10.3 Width of Trench

901.10.3.1 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	900
400	950
500	1100
600	1250
700	1400
800	1500
1000	2000
1100	2150
1200	2100
1300	2200
1400	2400
1500	2700
1600	2800
1800	3000

Structure excavation for box culvert shall be carried out for a width of at least 500 mm beyond the horizontal outside limits. Concrete blinding or sub-foundations are not to be considered as structure for the purpose of defining such excavation.

901.10.3.2 Width of Trench for Potable Water Network – 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 for potable water networks shall be as stated above in sub-clause 901.10.3.1 for sewerage and stormwater networks; except for pipe diameter less than 150mm the maximum trench width is specified as follows:

Single Pipe Trenches for Potable Water Network for pipe diameter less than 150mm

Pipe Diameter (mm)	Minimum Trench Width for Rigid Pipes (Ductile Iron or Galvanized Steel as applicable) (mm)	Minimum Trench Width for Flexible Pipes (PE) (mm)
Up to 50 mm	(Galvanized) 500	-----
60 to 100 mm	-----	D + 600
150 to 350 mm	(Ductile Iron) D + 450	-----
400 to 600 mm	(Ductile Iron) D + 700	-----

901.10.3.3 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 or that of the trench of box becomes greater than the above-mentioned values, the Contractor shall be instructed by the Engineer to check the adequacy of the pipe bedding stated in these Specifications. Any additional cost resulting from the change of pipe bedding due to the Contractor action of undertaking excavation 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.

901.10.4 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.

901.10.5 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.

901.11 Excavation for Foundations and Sub-Structures

Excavation for foundations and sub-structures shall be carried out to the lines and grades shown on 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.

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

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.

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.

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

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.

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.

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.

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.

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

901.12 Excavation Near Existing Utility Lines and Services

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.

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.

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 normal excavation, shall be deemed to be included in the Contractor's rates and prices for normal excavation.

901.12.1 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.

901.12.2 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.

901.12.3 Protection of Existing Structures and Utilities - 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.

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

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.

901.12.4 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.

901.12.5 Relocation and Replacement of Existing Services and Structures - 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. 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.

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.

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.

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.

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.

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.

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.

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.

901.13 Breaking Up Road Pavements

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.

901.14 Care and Restoration of Road Pavements and Structures

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.

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.

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.

901.15 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.

901.16 Filling and Backfilling for Pipe Trenches, Manholes and Chambers

901.16.1 General - 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.

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.

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 %.

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.

901.16.2 Backfilling Around Manholes, Chambers and Other Related Structures -

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.

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

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

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.

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.

901.16.3 Fill and Backfill Under Manholes, Chambers and Other Related Structures -

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.

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

901.16.4 Backfilling Pipe Trenches - 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.

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.

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.

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.

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

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

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.

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.

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.

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

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.

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.

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.

901.16.5 Selected Fill Material for Pipe Trenches - Selected fill material as bedding and surround to pipes shall consist of approved granular material (crushed rock aggregates), which shall exclude stones 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.

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

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

901.16.6 Suitable Fill for Pipe Trenches - 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.

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 Bill of Quantities.

902 – MATERIALS

902.01 General

902.01.1 Manufacturer's Certificate - Materials shall be supplied with certificates confirming that materials and products comply with the specified requirements and have been factory tested in accordance with applicable standards.

902.01.2 Manufacturer's Instructions - The Contractor shall observe the manufacturer's written instructions and recommendation in respect of handling, protection, stacking, storage, laying, fitting, cutting, repair of the products and materials as applicable.

902.01.3 Marking - All products shall be marked as appropriate to indicate factory name, reference standard, size, design pressure, class and other relevant details.

902.02 Ductile Iron Pipes and Fittings for Potable Water Networks

902.02.1 General - Ductile iron pipes, fittings, accessories and joints for potable water pipelines shall be of Class K9 pipes in conformance to BS EN 545. Pipes shall be to pressure rating suitable for the condition of service. Ductile pipes of minimum pressure rating of PN 16 shall be used for potable water works covered by this contract. All ductile iron pipes and fittings to be supplied under this Specification shall be obtained from an approved manufacturer having an ISO9001 TOTAL QUALITY ASSURANCE system based on the latest version of the ISO9001 standard.

902.02.2 Socket and spigot pipes

Ductile iron socket and spigot pipes shall be centrifugally cast. The nominal IRON wall thickness shall be Class K9 in accordance with the European Standard EN 545.

Each pipe shall be subjected, in accordance with the European Standard EN 545, to a hydrostatic works test at the following pressures:

DN	Hydrostatic pressure
	Bar
DN	CLASS K9
60 to 300	60
350 to 600	50
700 to 1600	40

902.02.3 Flanged pipes

Ductile iron flanged pipes shall be manufactured in accordance with the European Standard EN 545. The flanged joint ISO PN 16 or ISO PN 25 whose drilling shall comply with International Standard ISO 7005-2 ISO PN 16 or ISO PN 25 insures the water-tightness.

902.02.4 Fittings

The ductile iron fittings shall be sand cast in accordance with the European Standard EN 545.

The water-tightness is insured by the joint, which shall be of the:

- STANDARD push in joint where fittings are used with Socket and Spigot pipes.
- SELF-ANCHORED push in joint where the use of concrete anchor blocks is not recommended.
- MECHANICAL joint, if requested by the engineer and where it is recommended to install the fittings without any push-in force. The leak-tightness is provided by axial compression of an elastomer gasket, by tightening a gland with iron bolts & without the use nuts.
- FLANGED joint where fittings are used with flanged pipes.

Each fitting shall be subjected, in accordance with the European Standard EN545, to a work leak tightness test carried out under a one bar air pressure.

A certificate shall be carried out from an approved THIRD PART CONTROL ORGANISATION witnessing that the pipes and fittings are supplied from the same manufacturer unit plant.

902.02.5 Laying and Jointing of Ductile Iron Pipes

902.02.5.1 Laying

In addition to the requirements stated in this Section of the Specifications Under “WORKMANSHIP”, the following requirements stated in this sub-clause shall apply to the laying and jointing of the Ductile Iron Pipe:

Before laying the Ductile Iron pipe, all dirt and foreign matter shall be removed from inside of the pipes and all lumps blisters, excess coal tar, oil, grease and moisture shall be eliminated from the surfaces of the joints. After the pipe is laid and mounted, care shall be taken to avoid entrance of dirt, water and foreign matter from the trench or from elsewhere by use of tight bulkheads.

902.02.5.2 Jointing

Joints of Ductile Iron Pipes and Fittings shall be of the Push in automatic standard type and where there is a need to take up the axial forces, necessary Self Anchored push in joint shall be used.

For DN80 to DN1200 diameter the SELF-ANCHORED PUSH IN joint shall be as follows:

- The seal is provided by a leak-tightness STANDARD joint gasket
- The axial force transmission is through a mechanical arrangement,
 - Works applied weld bead on the pipe spigot
 - A one piece or segmented anchoring locking ring (depending on the diameter), with a curved external profile, which abuts against the weld bead.
 - A special gland, which blocks the locking ring.
 - Iron bolts (possibly special steel with baring plates in iron for high pressure and large diameter applications).

For DN1400 to DN1800 diameter the SELF-ANCHORED PUSH IN joint shall be as follows:

- The seal is provided by a leak-tightness STANDARD joint gasket
- The axial forces are transmitted by a mechanical arrangement, independent of the sealing function, comprising:
 - A weld bead, applied at works
 - A locking ring consisting of several segments held together by Elastomer Connectors.
 - A device known as a conformator, which transmits the axial force to the internal socket surface by means of shot filling the annular gap formed by the socket and conformator.
- The shot behaves like a fluid and ensures:
 - Distribution of the axial force on the socket surface and conformator
 - Automatic stretching of the main on assembly.

Any subsequent movement of the main during testing is consequently restricted to residual shot settlement.

Gaskets shall be elastomeric full-face 3 mm thick joint ring to BS 2494 and BS 3063. Rings shall be elastomeric to BS EN 681-2 to suit joint type. Bolts and nuts shall be isometric black hexagon to BS 4190, tensile strength 433 MN/m². Washers shall be black steel to BS 4320.

902.02.5.3 Lubricant paste

The lubricant paste shall be a mixing of Vaseline, non soluble in accordance with French standard AFNOR T90 M DOC8. The quantities used in the assembly joints shall be as per manufacturer recommendation. The Pipes and fittings manufacturer shall supply it.

902.02.5.4 Connecting pieces

All connecting pieces i.e. flexible coupling, flange adaptors, dismantling joint shall be made of ductile iron and shall be supplied from the same pipes and fittings manufacturer.

902.02.5.5 Pipes internal protection (including welded flanged pipes)

Pipes shall be internally lined with sulphate resisting blast furnace slag cement applied by a centrifugal process. The cement mortar lining shall be in accordance with the European Standard EN 545 & with the International Standard ISO 4179 with the thickness given in following table:

	Thickness of mortar	
	Nominal mean Value Mm	Tolerance Mm
80 – 300	3.5	- 1.5
350 – 600	5	-2
700 – 1200	6	-2.5
1400 – 2000	9	-3

902.02.5.6 Pipes external protection (including welded flanged pipes)

Pipes shall be externally coated with:

- A metallic zinc coating in accordance with the European Standard EN545 & the International Standard ISO 8179 Part 1-1995. The quantity of zinc shall not be less than 200 g/m².
- A bituminous varnish or equivalent anticorrosive paint which shall be applied over the zinc coating in accordance with the European Standard EN545 & the International Standard ISO 8179 Part 1-1995, with a minimum thickness of 100 microns.

902.02.5.7 Fittings Internal and external protection

The fittings shall be internally and externally protected with a bituminous varnish with a minimum thickness of 70 microns or with an epoxy coating applied by a process ensuring an equivalent protection.

902.02.5.8 Connecting pieces Internal and external protection

The connecting pieces (Flexible couplings, Flange adaptors, Dismantling joint) shall be internally and externally protected with a powder Epoxy coating having a minimum thickness of 150 microns or with a rilsan nylon coating having a minimum thickness of 200 microns.

902.02.5.9 List of Standards used as a reference in these specifications

Description	European Standard EN	International Standard ISO
Technical Specifications for D.I Pipes & Fittings	EN 545	ISO 2531 - 1998
AUTOMATIC Push In Joint	NF A 48-870 - 1981	-----
MECHANICAL Joint	NF A 48-860 - 1981	-----
Socket & Spigot D.I Pipes	EN 545	ISO 2531 - 1998
Socket D.I Fittings	EN 545	ISO 2531 - 1998
Flanged D.I Fittings	EN 545	ISO 2531 - 1998
Fixed & loose Flanges	NF A 48-840 - 1984	ISO 7005 - 1988
Erection & Installation of Flanges	EN 1092-2	ISO 7005 - 1988
Joint Gaskets. Material Specification	EN 681-1	ISO 4633 - 2002
Pipe Zinc Coating.	EN 545	ISO 8179-1 - 1995 *
Description	European Standard EN	International Standard ISO
Cement Mortar Pipe lining.	EN 545	ISO 4179-1 - 1985
Bolts with Hexagonal head	EN ISO 4014 EN ISO 4016	ISO 4014 ISO 4016
Hexagonal Nuts	EN ISO 4032 EN ISO 4034	ISO 4032 ISO 4034
Bolts & Nuts Zinc Coating	EN ISO 4042	ISO 4042

902.02.5.10 Tests & Certificates required from the manufacturer

Prior to any order, the contractor shall take an approval on the manufacturer of pipes & fittings. He shall submit a complete set of original catalogue and the following Certificates of conformity:

- The Certificate of conformity of the product to the EN 545.
- The Certificate of Quality Assurance of the Manufacturer to the ISO 9001 .

- The Certificate of compliance of the materials with the stipulations of the Health Authorities of the country of origin related to their use in the drinking water distribution application.
- An attestation from the manufacturer confirming that he will supply with the equipment all the Certificates related to the Tests required by the EN 545 and especially the Hydrostatic Tests and the Mechanical Tests.

The contractor shall submit with each order of pipes and fittings the following Test Certificates:

- Hydrostatic Tests Certificates to the EN 545 and as per the present specification requirement.
- Mechanical Tests Certificates to the EN 545.
- All other type of tests required in the EN 545.

These Certificates shall be issued by an approved third part control organisation.

902.03 Glass Reinforced Plastic (GRP) Pipe and Fittings for Sewerage and Stormwater Networks

902.03.1 General - GRP pipes shall meet the requirements of the most recent edition of ASTM D 3262 together with the requirements specified herein, GRP pipes and fittings shall be purchased locally provided they conform to these Specifications.

The Contractor shall supply to the Engineer, manufacturer's signed certificates stating that the pipes comply in all respects with the provisions of these Specifications and giving the results of all specified tests.

Other methods for manufacturing of GRP pipes may be proposed but such methods will be subject to the approval of the Engineer. Acceptable alternatives to the filament-wound type of pipe described above include the centrifugally cast type complying with BS en 14364 subject to independent evidence of a long record of satisfactory use and subject to the Engineer's approval of the detailed specification

902.03.2 Materials

902.03.2.1 Appearance - The internal surface of all pipes and fittings shall be smooth, hard, durable and free from all tack, protruding fibers, voids, pits, bubbles, cracks, blisters and foreign matter. The external surface of all pipes and fittings shall be a fiberglass surface mat impregnated with polyester resin and shall be commercially free of resin runs, dry areas, dirt and black marks.

The resin reinforcement and aggregates, when combined as a composite structure, shall produce pipes and fittings that satisfy the performance requirements of these Specifications.

902.03.2.2 Design Requirements - All pipes and joints shall be designed for a minimum working life of 50 years.

Pipelines may run beneath roads and be subjected to maximum loading conditions, therefore, design shall be for the worst surcharge conditions and loading applicable in Lebanon.

The pipe shall be designed to withstand the internal environmental conditions specified below:

pH value	1 to 13
BOD	up to 1000 mg/1
Suspended solids	up to 1000 mg./1
Chloride	1500 mg/1
Free NH ₃	150 mg/1
Sulphate	1000 mg/1
Temperature	5 to 50 °C
Prevailing temperature throughout sewage medium is:	30 °C
Sewage dissolved H ₂ S	Up to 20 mg/1
H ₂ S gas concentrations	Up to 2000 mg/1

The ground and groundwater in which the pipes shall be laid are high in salts and are aggressive.

902.03.2.3 Resins - Resins shall comply with the relevant requirements of BS 5480. Details of all resins to be used in the manufacture shall be provided and shall include all the properties listed in the table herein. The resin system adopted shall be that most suitable to the internal and external environmental conditions and resin properties shall be tested in accordance with the following table.

RESIN PROPERTIES

<u>Property</u>	<u>Test Method</u>	<u>Units</u>
Liquid Resin		
- Acid Value	BS 2782, BS 3532	mg KOH/g
- Viscosity at 25 deg C	BS EN 12350 & BS 3532	m Pas
- Specific Gravity	BS 3532	
- Volatiles content	BS 3532 &	BS 2782
- Refractive Index	ASTM D 1045	
<u>Cured Resin</u>		
- Heat distortion temperature	BS 3532 Appendix A	deg C
- Glass transition temperature	Differential thermal analysis	deg C
- Tensile strength	BS 2782	MN/m ²
- Flexural strength	BS 2782 & BS 3532	MN/m ²
- Ultimate elongation	BS 2782	
a. Basic resin		%
b. If flexibilised		%
- Barcol hardness	BS 4549 Appendix A	
- Water absorption	BS 2782 & BS 3532	mg

Information supplied on cured resin shall include details of the cure system employed, which shall be the same as that proposed for manufacture of pipes and fittings.

902.03.2.4 Fiber Reinforcement - With the exception of a veil on the inside face of the pipe, all fiber reinforcements used shall be of ECR/ADVANTEX type glass and shall comply with the appropriate standard listed below and shall have a surface treatment compatible with the resin.

BS EN 14020-1	Reinforcements. Specification for textile glass roving
BS EN 14118-1	Specifications for textile glass mats (chopped strand and continuous filament mats)
BS 3396	Woven glass fiber fabrics for plastic reinforcement
BS 3749	Woven roving fabrics of glass fiber for the reinforcement of polyester resin systems. If a veil is used on the inside face of the pipe, this shall be "C" glass fiber.

902.03.2.5 Aggregates and Fillers - Aggregates and fillers shall comply with the relevant requirements of BS EN 14364. Silica sand, if used in the manufacture, shall be a minimum of 95% pure silica. The maximum percentage by weight of all aggregates and fillers in the laminate(s) shall not exceed 30%.

No pigment shall be added to any resin used.

902.03.2.6 Liner - All pipes and fittings shall have a suitably reinforced resin rich liner to give high corrosion, impact and abrasion resistance. The thickness of this liner shall be

determined by the pipe manufacturer, but shall not be less than 1½ mm. No aggregate or fillers shall be included in the liner.

The liner shall consist of two layers, a surface layer and a barrier layer. The surface layer shall be a minimum of 1 mm thick with a minimum of 90% Venylester resin. Any reinforcement in this layer shall be of C type glass or approved suitable synthetic material. The barrier layer shall have 70% to 80% Vinylester resin with ECR/Advantex glass reinforcement.

902.03.2.7 Structural Design - Details of loading and pressures shall be as shown on the drawings. Pipes and fittings shall be designed to these standards for the ground conditions to be encountered. All pipes and fittings shall have a minimum stiffness of 5000 N/m² to accommodate handling and transportation stresses unless specified otherwise.

For buried pipes stiffness shall depend upon depth of cover above the crown of the buried pipe in accordance with the following:

- (a) For depths of cover over the pipe less than 4.5 meters, GRP pipe stiffness shall be minimum 5000 N/m².
- (b) For depths of cover over the pipe more than 6.0 meters, pipe stiffness shall be minimum 10000 N/m².

Note: Stiffness factor 'F' shall be calculated as follows:

$$F = \frac{EI}{d^3}$$

where, E = Flexural modulus of elasticity of pipe material in circumferential direction.

$$I = \frac{S^3}{12}$$

S = Wall thickness (m)

d = Mean pipe diameter (m)

Pipe shall have an initial ultimate resistance to longitudinal tensile force per unit of circumference of not less than the following:

DIAMETERS	RESISTANCE
Up to and including DN 600	150 N/mm ²
Greater than DN 600 up to and including DN 1200	200 N/mm ²
Greater than DN 1200 up to and including DN 2400	250 N/mm ²

902.03.2.8 Sizes and Tolerances

(i) Diameter

The diameter of the pipe shall be designated by the nominal internal diameter. The manufacturing tolerance of the internal diameter shall be in accordance with BS 5480.

All deviations from roundness, with the exception of pipe deformation due to its own weight, shall be contained within the tolerances. Deviations in diameter of spigot and sockets shall be kept to the absolute minimum and shall be such that the seal at the joints is not affected.

(ii) Length

Effective length of pipes and tolerance on effective length shall be as specified in BS EN 14364.

Where it is found necessary to cut or turn down a pipe in order to form a joint, the exposed surfaces shall be fully sealed with a continuous coating of fully cured resin.

(iii) Wall Thickness

Wall thickness shall be as recommended by the pipe manufacturer and to the approval of the Engineer.

902.03.2.9 Fittings - All fittings and collars such as bends, tees, junctions and reducers shall be equal to or superior in performance to pipes of the same classification and shall comply with BS EN 14364.

The use of metals for any part of these fittings will not be permitted. However, the Engineer may allow the use of fittings of other materials which are commonly used in the construction of sanitary sewers, provided that the design of fittings and pipes are mutually compatible.

902.03.2.10 Joints and Gaskets - Joints shall be of the collar type incorporating rubber rings. All joints shall be capable of withstanding the various tests specified for the appropriate class of pipe and shall withstand a deflection of not less than 1½ degrees in any direction while maintaining the specified test pressures.

Minimum requirements for the rubber rings shall be as specified in BS EN 681-2. Gaskets shall be of a thickness and design to provide watertight joints. The joints shall be qualified before installation with full testing according to ASTM D 4161. At least one test shall be carried out for each diameter. The Contractor shall ensure that the joint gaskets and joint ring are suitable for use in the prevailing climatic soil, ground water and sewage conditions.

All rubber rings shall be of the type that can pass an acid aging test as directed by the Engineer without any noticeable deterioration in the mechanical or chemical properties of the material used.

Flanged pipes shall incorporate an annular gasket at the joints. The gaskets shall cover the full face of the flanging and shall have holes cut in them corresponding to the bolt holes in the flanges. Alternative forms of gasket may be used, subject to the approval of the Engineer. Flanges shall be drilled to BS EN 1514-3, metric units, Type PN16.

902.03.2.11 Testing

(i) Raw Materials

a. Resins

All deliveries of resin shall be checked for consistency by viscosity and reactivity and refractive indices. Resins deviating from these Specifications shall not be used.

b. Glass

All deliveries of glass shall be checked for consistency by dry strength and chemical resistance to 1.0 N sulphuric acid. Pipes shall only be manufactured from batches of glass exhibiting similar strength and chemical resistant properties. Should these properties change due to variations in suppliers, the pipes produced from this glass shall be tested in accordance with the strain corrosion test as if they were different diameter or class. The Engineer may accept test reports of ECR glass as supplied by the manufacturer and testing of pipe factor glass may be dispensed with.

c. Sand or Aggregate

All deliveries of sand or aggregate shall be checked for consistency of grading, moisture content and purity.

(ii) Manufactured Pipe

a. Strain corrosion Test

Control testing shall be carried out during the manufacture of pipes in accordance with Section 6.3 of ASTM D 3262 using the specified test solution. Control tests shall be carried out for each diameter and class of pipe.

In the event regression curves are not available or any changes to the pipe wall and laminate build-up and/or the properties of the raw materials at any time during the manufacture of the pipes, two complete sets of corrosion tests (including a regression curve) shall be carried out in accordance with ASTM D 3681. One set shall use a 10% W/W solution of sulphuric acid maintained at a temperature of $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The other set shall use a 5% W/W solution of sulphuric acid maintained at a temperature of 23°C .

Strain corrosion tests shall be run on a minimum of 6 samples from each lot of pipe diameter to ensure that they fall above the regression curve values defined by the manufacturer.

b. Hydraulic Tests in Factory

All pipes shall be subjected to an internal hydraulic pressure test at the manufacturer's plant prior to delivery. The test shall be applied to a pressure equal to two times the working pressure or 6 bars of water head whichever is higher. The test pressure shall be applied for a minimum period of 5 minutes without signs of leakage.

All fittings shall be subject to an internal low pressure test at the manufacturer's plant prior to delivery. The pressure test shall be carried out at 0.1 bar and shall be applied for a minimum period of 5 minutes without signs of leakage or distress. Fittings of metric construction shall be manufactured from pipe which has successfully passed the tests defined above.

c. Stiffness

A minimum of one pipe in every 30 pipes, one per shift, or one per production run, whichever is less, shall be tested for stiffness in accordance with ASTM D 2412 "Test for External Loading Properties of Plastic Pipe by Parallel Plate Loading". A minimum of one pipe for each size shall be tested.

d. Longitudinal Tensile Strength

For pipes with internal diameters of 600 mm and less, a minimum of one pipe in every 1000 pipes manufactured shall undergo a beam test in accordance with ASTM D 3262, Section 8. A minimum of one pipe for each size shall be tested.

e. Curing/Hardness Test

All manufactured pipes shall be subjected to both a Barcol Hardness Test in accordance with BS 4549, Part 1, Appendix A and a commercial acetone test. Both tests shall be carried out on internal and external pipe surfaces.

f. Loss on Ignition

A minimum of one pipe for every 30 pipes, one per shift, or one per production run, whichever is less, shall be tested in accordance with ASTM D 2584. From each test pipe, two samples shall be taken for test.

One sample shall comprise the complete laminate including the liner. The second sample shall comprise the laminate without the liner and shall be split off at the interface between the liner and the structural wall.

g. Other Test and Compilation of Data

Quality control testing shall include thorough checks of all materials to ensure that they comply with the relevant standards and requirements of the Specifications. All pipes and fittings shall also be subject to a complete visual inspection before shipment. Records of all tests and inspections shall be maintained by the manufacturer and two copies of all test certificates shall be forwarded to the Engineer.

In addition, the Contractor shall submit all necessary data and manufacturer's specifications of the GRP pipes and joints, including details of raw materials, pipe design, manufacturing process, laying instructions and all other relevant information required by the Engineer.

h. Test Failure

In the event of a pipe failing the strain corrosion test, two more tests shall be performed: one on a pipe from the previous five pipes and one on a pipe from following five pipes, if any of these two pipes fails, all pipes of that diameter and class which have been manufactured shall be rejected and shall be replaced entirely at the Contractor's expense.

Pipe failing any other test shall be rejected and an additional ten pipes shall then be tested. Five of these pipes shall have been sequentially produced immediately prior to the failed pipe and five immediately following. If anyone of these ten pipes fails, then every pipe shall be tested. Only pipes passing the tests will be accepted.

All pipes and fittings will be subjected to a visual inspection by the Engineer after offloading at Site. All pipes and fittings that have been damaged during delivery shall be repaired and/or replaced by the Contractor and the pipe shall be subject to a further hydraulic test to be carried out by the Contractor as specified herein. Such making good and hydraulic testing at site shall be entirely at the Contractor's expense.

i. Marking and Identification

All pipes, including cut lengths and fittings shall be indelibly marked prior to delivery in the order given below with:

1. The manufacturer's name, initials, or identification mark
2. The nominal internal diameter in mm
3. The classification, i.e. pressure rating stiffness (to avoid confusion, pipe rated at 2.5 or 12.5 bars shall be marked 2½ or 12½ and not 2.5 or 12.5).
4. The date of manufacture.
5. A suitable stamp to indicate that the pipe has satisfactorily passed the required inspection and hydraulic tests at the manufacturer's plant.

These markings may be arranged either in one line or in several lines provided that the order is preserved.

j. Third Party Inspection

All tests shall be supervised and certified by a third party inspection agency approved by the Engineer. All costs for the inspection agency shall be borne by the Contractor and shall be included in the cost of the pipe.

All pipes shall be visually inspected on site prior to installation. The pipes shall be free of defects such as delaminating, air bubbles, protruding or exposed fibers, cracks, air holes, surfaces non-impregnated with resin which can affect, due to their extent, the rigidity and usefulness of the pipe. Defects extent shall be defined by Manufacturer and approved by the Engineer.

The surface of the pipe joints shall be free of all defects and surface irregularities that can affect their integrity. All repairs effected on site shall be agreed to by the Engineer and conducted by qualified personnel from the pipe manufacturer.

902.03.2.12 Loading, Unloading and Transportation of Pipes - GRP pipes are made of delicate elastic materials and, therefore, require special care in loading, unloading and other handling. Nylon lifting strings shall be used for loading and unloading of pipes. Pipes shall not overhang trucks or trailers while being transported and shall be securely tied. Avoid sudden drops or motion while loading and unloading.

902.03.2.13 Storing Pipes, Fittings and Accessories - Pipes shall be stored on flat ground having no stones or debris to prevent any damage to the pipe barrel. It is advantageous to store pipes on timber pieces to facilitate placement and removal of lifting strings. Storage of pipes in heights over 2 m shall be avoided. All pipes shall be properly secured to prevent rolling in high winds.

Rubber ring gaskets shall be stored in the shade in the original packing. The store shall be air-conditioned during summer. Gaskets shall be protected from exposure to greases, oils, solvents, or any other petroleum derivatives or chemicals.

Gasket lubricant shall be carefully stored to avoid damage to the container. Partially used buckets shall be properly resealed to prevent contamination of the lubricant. If the lubricant is contaminated by any foreign substance it shall be abandoned.

902.04 UPVC Pipes for Sewerage and Stormwater Networks

902.04.1 General - Where indicated in the Bill of Quantities and shown on drawings, UPVC pipes shall be used for sewerage and stormwater networks.

902.04.2 Requirements -

“ uPVC pipes and fittings for sewerage and stormwater networks shall be manufactured and installed in conformance to the following Standards:

-BS EN 1401-1 – Plastic Piping for non pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system

-DIN 4262 -Part 1 – Plastic Pipes

-DIN 8062 -Unplasticized polyvinyl chloride (PVC-U, PVC-HI) pipes – dimensions. Pipe shall be of Class 6.

-ISO 161/1 latest version - Thermoplastics pipes for the transport of fluids - Nominal outside diameters and nominal pressures - Part 1 : Metric Series. Pipe shall be of Class 6.

Joints shall be to BS EN 1401-1 of the socket and spigot type with rubber sealing conforming to the latest version of (BS EN 681-2 - Materials for Elastomeric seals for joints in pipework and pipelines).”

902.05 Polyethylene (PE) Pipes for use in Potable Water Network

902.05.1 General - Polyethylene (PE) pipes for use in potable water network shall be of PE-100 materials and in compliance with Lebanese Standards NL 5/2-2:2001 or equivalent (PR EN 12201-2) of the most recent edition, for the applicable trench structural loading and internal pressure but not less than PN 16.

902.06 Concrete Pipe for Stormwater Networks

902.06.1 General

This Section covers the Specifications of concrete pipe which shall be used for the Sewer pipelines.

The contractor shall submit the required test data and the proposed layout of the piping, pipe lengths, segment weights, joint details and all items pertinent to the work, to the Engineer for review prior to delivery of such item to the project site.

The Contractor shall provide the Engineer with a Certificate of Compliance that the pipe and concrete mix conform in all respects to Specifications and other nonconflicting requirements of the referenced ASTM Specifications.

902.06.2 Materials

a. Pipe

1- Cement shall be Sulfate Resisting Cement Type V conforming to ASTM C 150.

2- Aggregates

2-1 Grading of coarse and medium aggregates shall comply with the requirements of ASTM C33.

Grading of mixed fine aggregate and natural sand shall satisfy the requirements of BS EN 12620 with a finess modulus to ASTM C136.

2-2- Water soluble chlorides and sulphates for every type of aggregate shall meet the requirements of BS EN 1744-1.

3- Concrete pipe shall be one of the following:

-Reinforced Concrete Pipe: In conformance to ASTM C76 (Class V)

-Non-reinforced Concrete Pipe: Non-reinforced Concrete Pipe shall be manufactured and tested to DIN 4032. The required non-reinforced concrete pipes shall not fail under the D-Load crushing tests conducted to DIN or ASTM standards for the minimum loading tabulated in this Section of the Specifications.

All pipes shall be internally coated with coal tar epoxy. The dry film thickness of the coating shall not be less than 650 microns.

The following additional requirements shall be met:

- a. The minimum Cement content shall not be less than 360 Kg per cubic meter.
- b. The water/cement ratio shall not exceed 0.47.
- c. Curing shall conform to the requirements of AWWA C302.

Each piece of pipe shall be clearly identified as to class and date of manufacture.

(i) Method of Manufacture

The pipe shall be manufactured using the vibropressing technique. When placing the concrete in the forms, the concrete shall be vibrated with external mechanical vibrators in an approved manner so as to prevent "honeycombing" of exposed finished surfaces.

(ii) Curing

1. General: The Contractor's manufacturing plant or the plant of his pipe supplier shall provide adequate steam plant, piping, enclosures and other facilities for curing the pipe. The enclosures shall be such that the temperature and humidity can be controlled to keep the pipe surfaces moist at all times and the temperature maintained continuously between limits described below.
2. Pipe shall be subjected to any one of the methods of curing described in AWWA C 302 and hereinafter, or to any other method or combination of methods approved by the Engineer that will give satisfactory results. The pipe shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less. Crushing (compressive) tests shall be performed on test cylinders or cured pipe cylinder utilizing test methods in compliance with ASTM C 497M or BS 5911.
3. Accelerated Curing (Alternative Method): The pipe shall be placed in a curing facility or otherwise covered by a suitable enclosure that shall allow

proper circulation of moist air or steam. Until the initial set of the concrete occurs, the ambient temperature within the enclosure shall not be less than 15 C and shall not be raised above 38 C by the introduction of heat. After a delay period of one to four hours, the temperature shall be increased at a rate not to exceed 22 C per hour and thereafter maintained at a temperature between 32 C and 66 C.

4. Water Curing: Water curing shall begin as soon as the concrete has set sufficiently to prevent damage to the exposed concrete surfaces. The total cure, consisting of the water cure and the ambient air cure, shall be sufficient to produce the concrete strength required.
5. Combination Curing: Curing of pipe may consist of any combination of accelerated curing and water curing.

(iii) Forms

The forms for the pipe shall be of steel made with butt joints throughout and the surfaces of the forms adjacent to the pipe walls shall be smooth and true. All forms shall be sufficiently tight with suitable gaskets provided at all form joints to prevent leakage of mortar. The forms shall be braced and sufficiently stiff to withstand, without detrimental deformation, all operations incidental to the placement and compaction of concrete within the form. The form and end rings shall be so constructed that the pipe when manufactured shall have circular and cylindrical inner surfaces and so, that they may be stripped from the pipe without damage to the pipe or its surfaces.

Forms shall be cleaned and oiled at the start of each day of continuous production. Defective forms and end rings shall be discarded or adequately repaired to the satisfaction of the Engineer.

b. Pipe Joints

The concrete pipe shall have a flared bell and spigot joint or flush bell design with confined synthetic rubber compound gasket conforming to DIN 4060 and BS EN 681-2. The bell and spigot gasket joint mating length shall provide allowance for the maximum possible joint deflection, preset joint opening to allow for joint deflection, joint creep and safety allowances to ensure positive gasket sealing during joint movement. The jointing system shall guarantee zero leakage at 0.5 bar pressure and the joints lifetime at normal temperature conditions to be about 100 years.

c. Joint Lubricant

Furnish joint lubricant with the pipe. Furnish the amount and type recommended by the pipe manufacturer. The lubricant shall be a water-soluble, non-toxic, vegetable soap compound conforming to United States Pharmacopoeia No. P 39.

d. Feeler Gauge

Furnish sufficient feeler gauges of the proper size, type and shape for use by the installation contractor and Engineer's representative to check the rubber gasket joints.

902.06.3 Material Test and Inspection

The Engineer and his representatives shall have access to all phases of the work and the manufacturer shall provide proper facilities for access and inspection. Material, fabricated parts and pipe which are discovered to be defective, or which do not conform to the requirements of these Specifications, will be subject to rejection at any time prior to final acceptance of the pipe.

Acceptance of all concrete pipes, manufactured under these specifications shall be on the basis of external load-bearing tests, material tests, concrete compressive strength tests, joint performance and permeability tests and inspection of manufactured pipe for dimensional conformance and freedom from visible defects and imperfections.

(i) Load Bearing Tests

As part of the Criteria for acceptance for the reinforced and the non-reinforced concrete pipes, the result of the load bearing tests conducted on these pipes should pass the requirements of ASTM C76 (Class V) for the reinforced concrete pipes and the requirements of DIN 4032 for the non-reinforced concrete pipes. The reinforced concrete pipes shall be tested and subjected to the loading requirements in conformance with ASTM C76 (Class V); the non-reinforced concrete pipes shall be tested to DIN 4032 or ASTM C76 and shall be subjected to the loading requirements tabulated below:

Minimum Crushing Loading (D-Load) for the testing of Non-reinforced concrete pipes

Non- Reinforced Concrete Pipe Diameter, mm	Minimum Required Crushing Load (under D-load Test) to Be applied to non-reinforced concrete pipe without failure, KN/m.
300mm	50
400mm	63
500mm	80
600mm	90

Test specimens in the required number stated in ASTM C76 or DIN 4032 shall be furnished and tested at the Contractor's expenses.

(ii) Core Tests

Two cores shall be drilled from the pipe wall of each load bearing test pipe to determine specifications compliance with the Specifications. Cores shall be taken and tested in accordance with ASTM C 497.

(iii) Cylinder Tests

At least 7 test cylinders for compressive strength shall be cast from each day's concreting. Where more than 40 cubic meters of concrete are cast in a day, a set of seven test cylinders shall be cast from each 40 cubic meters of such concrete placed that day. The rate of cylinder casting may be varied by the Engineer to establish or confirm control levels. Three cylinders from each set shall be tested at age 7 days and three at age 28 days. The remaining cylinder shall be tested when directed by the Engineer. The 28 days concrete compressive strength shall not be less than 34 MPa.

The cylinders shall be cured in the same manner as the pipe which they represent.

(iv) Hydrostatic Tests

Pipes shall withstand an internal hydrostatic pressure of 0.14N/mm² (14m head of water) and bends and junctions shall withstand a pressure of 7m head of water, as per BS5911.

(v) water absorption as per BS 5911 shall not exceed 6.5% in 24 hours.

(vi) Dimensional Tolerances

Each pipe shall be dimensional checked prior to delivery of the pipe to the job site. Pipe shall be subject to rejection for failure to conform to the following dimensional tolerances:

1. The internal diameter shall not vary by more than ± 6 mm from the specified size.
2. The squareness of the pipe ends shall be determined by taking diagonal measurements from the face of the spigot to the shoulder of the bell at the $\frac{1}{4}$ points on the circumference of the pipe. The maximum variation between measurements shall be limited to 10 mm.
3. The roundness shall be determined by taking diameter measurements at the $\frac{1}{4}$ points across the inside of the bell, outside of the spigot and inside of the pipe barrel. Maximum variation between measurements shall be 2 mm at the joint and 6 mm in the pipe barrel.

Pipe shall be subject to rejection for failure to conform to any requirements of the Specifications or for any of the following:

1. Chips, fractures, cracks, or irregularities in the pipe joint and gasket bearing area.
2. Spalls, fractures, cracks or irregularities in the thrust bearing area of pipe to be jacked. Minor repairs will be permitted if they are of a quality at least equivalent to that of a new pipe.

3. Chips, fractures, or air pockets on the interior of the pipe exceeding 5 cm in length, 2 cm in width and 1 cm in depth.
4. Defects that indicate improper proportioning, mixing and molding.

902.06.4 Pipe Coating

The external surface of the pipes shall be coated with three coats of approved rubber bitumen emulsion. Application of the emulsion shall be carried out strictly in accordance with manufacturer's instructions.

902.06.5 Marking

The following markings shall be stamped on each pipe delivered to Site:

- Factory Name
- Reference Standard
- Design Pressure
- Class and Wall Type
- Inspection Agency

902.07 Geotextile Fabric

Geotextile fabric shall be provided and installed when directed by the Engineer. The geotextile shall be a pervious sheet of nonwoven polyester, polyethylene, nylon, or polypropylene filaments and formed into a uniform pattern. The geotextile shall have the following minimum properties when measured in accordance with the reference standards:

Test	Minimum Property	ASTM Standard
Grab tensile strength	58 kg	D 1682
Trapezoidal tear	32 kg	D 2263
Mullen Burst	0.83 N/mm ²	D 751

The geotextile shall be finished so that the filaments will retain their relative position with respect to each other. The edges of woven fabric shall be finished to prevent the outer material from pulling away from the fabric. Provide manufacturer's certificates of compliance attesting that the geotextile meets the requirements of these Specifications. Provide mill certificates stating the length and width of fabric contained on each roll.

Prevent exposure of geotextile to light until needed for construction. Geotextile laying and subsequent covering with succeeding layers of trench backfill shall proceed in such a manner as to limit exposure to light for a maximum of 24 hours.

The surface to receive the geotextile shall be smooth, free from obstructions, depressions and sharp objects. Lay geotextile so as to minimize the number of joints and seams. Lay geotextile loosely, but without creases. Provide at least 2 feet of overlap at the joints. The geotextile shall extend up the sides of the trench to at least 2 feet above the top of pipe.

Do not operate machinery directly on the geotextile. When placing material over joints place in the direction from the overlaying geotextile to the underlying geotextile. Prevent puncture, tear, or displacement of geotextile and prevent from damage. Replace torn areas and holes by placing an overlay of geotextile having dimensions at least 2 feet greater than the tear or hole.

902.08 Materials for Manholes, Chambers, Inlets, etc.

902.08.1 Concrete Components - Concrete components such as cement, aggregates, water, reinforcement, formwork, testing etc., shall be as specified in the concrete section of these specifications.

902.08.2 Pipes and Pipe Fittings - Pipes and pipe fittings shall be as specified in the present section.

902.08.3 Manhole Covers and Frames

Manhole covers and frames shall be of cast iron, to BS EN 124 and to the following Classes:

- Traffic C.I manhole frames and covers: (In roadway pavements; test load 40 tons)
- Non traffic C.I manhole frames and covers: (In driveways, medians, sidewalks and similar non-traffic applications; test load 25 tons).

The cover shall hold the name and “ badge” of the Official Authority in charge of the specific utility considered in each case. The name shall be cast to the standard format, size and other requirements of the respective Authority.

Manufacturer shall have minimum experience of 10 years in the field of manufacturing manholes covers and frames. Samples of the manhole covers and frames along with manufacturer qualification, product data sheet and details catalogues, Quality Control procedures, Certificate of compliance of the covers and frames intended to be incorporated in the Works to above mentioned standards issued from third party approved testing agency shall all be submitted for the approval of the Engineer

902.08.4 Steel Ladders - Steel ladders shall be galvanized mild steel conforming to BS 4211 and BS EN ISO 1461.

902.08.5 Safety Chains - Safety chains shall be wrought iron short link, 12mm diameter galvanized to BS EN ISO 1461.

902.08.6 Levelling Bricks - Levelling bricks used for adjusting the height of cast iron covers to road levels shall be of concrete Class A as specified under " Concrete Work". Bricks shall be radial or tapered in shape 20 cm. long and 5 cm. thick, cast at least three weeks before use and properly cured. Any cracked or defective bricks shall be rejected.

902.08.7 Samples - The Contractor shall submit samples of all types of cast iron frames and covers, mud collection buckets and step irons for approval by the Engineer before placing orders or importation to the Site.

902.09 Galvanised Steel Pipe for use in Potable Water Network

902.09.1 General – galvanized steel pipe shall be used in potable water network where shown on drawings and as stated in the Bill of Quantities.

902.09.1 Requirements- Galvanised steel pipes for use in potable water network shall be in conformance with BS EN 10255 – Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS EN 10266-1 pipe threads.”

902.10 Gate Valves

902.10.1 General - Valves for normal duty on water pipelines with pressure up to PN25 shall be key operated cast iron flanged gate valves for waterworks purposes generally complying with the requirements of BS 5163 (type B).

Cast iron gate valves for pressure ratings up to PN25 shall be cast iron flanged valves complying with BS 5150 or cast iron parallel slide valves complying with BS 5151.

Gate valves for pressure ratings of between PN25 and PN40 shall be steel parallel slide flanged gate valves complying with BS 5157.

Butterfly valves for pressure ratings of up to PN40 shall be double-flanged wafer type butterfly valves complying with BS 5155.

Valves for pressure ratings in excess of PN40 shall be flanged cast iron carbon steel ball valves complying with BS 5159.

Unless otherwise specified valves for use on steel pipes shall be flanged, where butt-weld ends are specified valves shall comply with BS 5157, or BS 5160.

902.10.2 Wedge Gate Valves for Manual Operation - Valves up to and including DN300 shall be of the resilient seal type and valves larger than DN300 shall have metal seals.

Spindles shall be of the non-rising type and screwed so as to close the valves when rotated in the clockwise direction. The direction of closing shall be clearly cast on the valve cap or hand wheel as appropriate.

The valves shall be constructed of the following materials.

Body	-	cast iron
Spindle	-	forged bronze or stainless steel
Metal faces and seal	-	gunmetal.

The valves shall be suitable for the unbalanced head as specified or indicated in the schedules.

Suitable gearing and anti-friction devices such as ball bearing thrust collars shall be provided as necessary to enable opening and closing by manual operation at the pressure stated, using an effort no greater than 26 kg on the tee key or handwheel supplied. Handwheel shall not exceed 500mm diameter. A bypass with gate valve forming an integral part of the valve shall be provided where recommended by the valve manufacturer for the pressures specified.

Gearing on valves of DN 300 and less shall be enclosed in a sealed gearbox suitable for buried installation and operation with a tee key. Except where shown on the Drawings, all valves exceeding DN 300 shall be provided with bevel gearing and handwheels.

Valves to be used for washouts and isolating air valves shall have screwed seats.

Extension spindles shall be galvanized or stainless adequately supported with cast iron brackets, and of sufficient diameter to prevent any whiplash effect through twisting when being used to operate the valves. The spindles shall be capped for key operation.

Valve caps shall be fitted with hexagonal set screws.

Valves shall be coated with cold applied bitumen conforming to the requirements of BS 3416 (material Type II).

Keys for valve operation shall be of sufficient length so that the valves can be operated by a man standing, but shall not exceed 1.2m in length, and shall have a detachable cross bar.

All valves shall be open end tested in accordance with BS 5163, and pressure and materials test certificates shall be submitted to the Engineer for approval.

902.11 Air Valves

Air valves shall be either:

- a) Single (small) orifice valve (SAV), for the discharge of air during the normal operation of the pipeline.
- b) Double orifice valves (DAV), consisting of a large orifice and a small orifice. These shall permit the bulk discharge of air from the main during filling and air inflow when emptying in addition to the discharge of small quantities of air during normal operating conditions.

Air valves shall be supplied with an independent isolating butterfly valve (DAV) or cock (SAV), which permits the complete removal of the air valve from the main, without affecting the flow of water in the main.

Each air valve assembly shall be suitable for connection to a flange on the pipeline.

At the connection between the air valve and its isolating valve a BSP tapping shall be made suitable for fitting of a pressure gauge. All tappings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

902.12 Surface Boxes and Chamber Covers

Surface boxes and chamber covers shall be either cast iron or ductile iron and coated with a black bituminous solution.

Surface boxes over gate valves shall be hinged and chained and shall generally comply with BS 5834.

-In roads, tracks, verges: Heavy duty with 150 x 150mm nominal clear opening.

-In fields and areas subjected to light wheeled or pedestrian traffic: Medium duty with 150 x 150mm nominal clear opening.

Surface boxes for hydrant chambers shall have a 380 x 230mm clear opening and shall comply with BS 750 and shall be suitable for heavy traffic loading.

Covers to air valve and other chambers shall be to the dimensions and loading requirements shown on the Drawings or as stated in the Bill of Quantities.

Covers shall be suitable for the following maximum safe center static loads:

Light duty	–	250 kg
Medium duty	–	1500 kg
Heavy duty	–	5000 kg

Where applicable, covers shall comply with BS 497 or other appropriate Standard.

Lifting keys shall be provided for each type of surface box or cover supplied. One set of keys shall be provided for every ten surface boxes or covers subject to a minimum of ten sets of keys or the actual number of covers if less than ten.

902.13 Steel Pipes and Fittings

902.13.1 General – Steel pipes shall be installed bracketed to the bottom of the bridge slab. The contractor shall submit for the Engineer approval all related data including, type of materials and its compliance with required Standards, Testing certificate, previous projects where the submitted pipes were used for similar installation conditions, shop drawings and detailed drawings, including jointing details and materials with testing certificates proving the durability and water-tightness of jointing and sealing materials, bracketing details including supporting materials and accessories.

902.13.2 Materials & Design Requirements - Materials and design requirements shall be in conformance with BS 534: 1990 – Specification for Steel Pipes, Joints and Specials for Water and Sewage.

903 – WORKMANSHIP

903.01 Laying of Pipes

903.01.1 General - Each type of pipe or joint, immediately before being laid, shall be carefully brushed out and tested for soundness and any pipe or joint which shows any sign of being defective, shall be rejected.

The Contractor shall adopt such measures as may be approved by the Engineer to ensure that every newly laid pipe is concentric with the previously laid pipe with which it joints.

Unless otherwise approved by the Engineer, pipes shall be laid in an upstream direction and the sockets of spigot and socket shall point upstream.

Before commencing the laying operation, the Contractor shall ensure that the portions of the pipe which will come into contact with the jointing materials are perfectly clean.

Each pipe shall be laid accurately to line, level and gradient so that, except where otherwise provided, the finished pipe line shall be in a straight line both in horizontal and vertical planes.

The pipes shall be laid and jointed immediately following excavation. The pipes shall be laid at the level and gradient as shown on the Drawings. The pipes shall be bedded as indicated on

the Drawings. The pipes shall be aligned carefully both in line and level. Except where the pipe is to have a concrete bed or surround, supports shall not be placed under the pipe. The bedding shall be shaped and scooped out at pipe joints to ensure the pipe rests only on the barrel of the pipe and not on any widening at the joints. Joints shall be free from dirt and grease.

The Contractor is to exercise extreme care in making joints, including constructed to manholes and other appurtenances to ensure that no leakage whatsoever occurs from the joints.

The Contractor shall ensure that all pipes and structures, when laid as constructed, are secured against floating by backfilling or by some other approved means.

The Contractor must obtain the fullest possible information on the variations in water table and water level fluctuation that may affect the Works and shall carry out work having due regard to this information.

No " Y " connections to laterals shall be made. All connections shall be made directly to the manholes. When such direct connections are not possible, a solution shall be proposed by the Contractor for the Engineer's approval.

Any special instructions, including the use of specialized tools by the manufacturer of pipes and pipe joints for the laying, field cutting and turning pipes, shall be adhered to strictly and shall be deemed to be part of the Specifications unless contrary instructions are issued in writing by the Engineer.

Properly fitted temporary rubber stoppers shall be provided and constantly used to close the ends of all uncompleted pipe lines. The stoppers shall only be removed when pipe laying and jointing starts again from that end.

When a pipe passes through a wall and is encased in concrete, such as a connection to a manhole, a socket shall be fixed while casting the structure and the layout of the pipeline shall include a joint within one to two pipe diameters of the connection, as shown on the drawings or as directed by the Engineer.

If hard rock is encountered under the pipe, a flexible joint shall be provided at the starting point as well as on the ending point of the section with hard rock. Such joints shall reduce shearing of the pipe at the interface of the hard and soft bedding material and possible differential settlement between the two materials.

No pipe shall be laid when climatic conditions, in the opinion of the Engineer, are unsuitable.

903.01.2 Additional Specifications for Laying GRP Pipes - The deflections of every pipe at the spigot, mid-point and socket shall be checked after the laying of each pipe length.

Case A - After the pipe surround material has been placed and compacted to 300 mm above the pipe crown.

Case B - On completion of all backfill material up to final ground level but before the dewatering is removed.

Case C - Immediately prior to the issue of a completion certificate.

Pipes exhibiting any negative deflection in the vertical in Case A and/or pipes exhibiting a deflection in excess of the initial deflection stated in the pipe design under Case B shall be exposed and the surround replaced and re-compacted. Should any deflection exceed the long-term deflection stated in the pipe design by more than 30%, that pipe shall be taken from Site and not incorporated in the permanent Works.

Pipes exhibiting a deflection in excess of the long-term deflection in Case C shall be exposed and the surround replaced and recompacted. Should the deflection exceed the long-term deflection by more than 30%, the pipe shall be rejected and replaced as specified above.

All pipes exposed for recompaction and those replaced shall be subject to the same three deflection checks specified above.

- Initial deflection in Case A shall not exceed 1%
- Initial deflection in Case B shall not exceed 2%
- Longterm deflection in Case C shall not exceed 2.5%

GRP pipes shall not be used where native soil bedding is classified as soft or very loose soil as per ASTM MH, CH, OL and OH (OR ATV type 4).

For Soil Classification of Group 3 and above, GRP pipes can be used and manufacturer to submit pipe laying calculations as per ASTM D3839.

The Contractor shall provide suitable mechanised devices for gauging the deflections to the approval of the Engineer. Pipes 800 mm and larger only may be inspected visually.

Any cut end of GRP pipe shall be properly sealed with resin.

When it is essential to surround GRP pipes in concrete, care shall be taken to avoid buoyancy of the pipe in the concrete and also deformation due to excessive hydraulic pressure of the concrete while it is still in fluid state. To achieve this, it is essential to pour the concrete in small layers not exceeding 30 cm and each successive layer laid only after the previous layer has solidified. To facilitate proper concrete pouring beneath the pipes, precast concrete supports shall be provided under all pipes as shown in the Drawings. Strap anchors can also be provided to keep the pipe in position and to avoid buoyancy while pouring the concrete. Such straps shall be tied securely to the base and shall be used at spans of about 4 m.

In addition to the above, the Contractor shall follow the manufacturer's instructions for laying and handling GRP pipes. Under all abnormal site conditions, the manufacturer's recommendations shall be followed strictly.

903.02 Jointing pipes

The Contractor shall submit to the Engineer the type of jointing he proposes for the various types of pipes.

Pipes shall be jointed in accordance with the manufacturer's instructions and the directions given by the Engineer. The Contractor shall adopt all measures as may be directed or approved by the Engineer to ensure that every newly laid pipe is concentric with the previously laid pipe to which it is jointed.

All joints must remain absolutely watertight and shall withstand the pressure and tightness tests specified as the case may be. Any joint showing cracks, loss or sweating, shall be remade and again tested until, a satisfactory result is obtained. All costs for jointing and for remaking of unsatisfactory joints shall be included in the items for the complete pipe line.

The Contractor shall ensure that the portions of the pipe which will come into contact with the jointing material are perfectly clean and dry.

The jointing materials shall withstand, without any alteration or modification for a period of at least the same as that for the barrel of the pipe, all stresses and strains to which they may be subjected as well as all chemical or physical attack from sewage or ground water as might be expected and the Engineer reserves himself the right to demand a guarantee of the manufacturer of the jointing material.

The joints shall be to the latest average label standards utilized by the pipe manufacturer and approved by the Engineer.

Cement mortar joints or similar joints shall in no case be accepted.

All costs for jointing and remaking of unsatisfactory joints shall be included in the items for the complete pipeline.

903.03 Backfilling

All backfilling of pipe trenches shall be carried out in accordance with Clause 901 of this section.

903.04 Prevention of Migration of Backfill Material

Where there is a likelihood that backfill material may flow into the voids of surrounding soil due to fluctuations in the ground water table, the Contractor shall use a suitable filter fabric to surround the backfill within the pipes zone completely with overlaps as recommended by the manufacturer. The filter fabric shall have a minimum design life of 50 years.

In all cases, the Engineer shall direct and approve the use of filter fabric to surround the backfill in pipe zone.

903.05 Pipe Bedding and Surround

Unless otherwise instructed by the Engineer pipe bedding for each type of pipe shall be in accordance with the following table. Any increased bedding requirements deemed necessary by the Engineer due to excessive trench widths being excavated, shall be carried out at the Contractor's expense.

Table of Requirements of Pipe Bedding and Surround

Pipe Material	Height of Fill above pipe: From Ground level To Crown of Pipe	Type of Installation (Bedding Requirements)
For All Pipe Materials	Less than 1.00m	Concrete Encasement
GRP Pipe	1m – 3m	Granular Bedding and Surround
	3m – 4.50m	Cement Stabilized Sand Bedding and surround
	Greater than 4.50m	Concrete Encasement
Non-Reinforced Concrete Pipe to DIN 4032	1m – 4m	Compacted sand fill or Granular material of pipe bedding and surround to a minimum of 300mm height above pipe crown and backfilled with Selected excavated material
	Greater than 4m	Concrete Encasement
Reinforced Concrete Pipe (ASTM C 76M – Class V)	1m – 6m	Compacted sand fill or Granular material of pipe bedding and surround to a minimum of 300mm height above pipe crown and backfilled with Selected excavated material
	Greater than 6m	Concrete Encasement
Ductile Iron Pipe	Greater than 1.00m	Compacted Sand Fill or Granular material of minimum 300mm height above pipe crown and backfilled with Selected excavated material
U-PVC Pipe: Class 4 (Dia. 315mm) / HDPE Pipe	1m – 4m	Granular Bedding and Surround
	Greater than 4.00m	Concrete Encasement
Steel Pipe	Greater than 1.00m	Compacted Sand Fill or Granular material of minimum 300mm height above pipe crown and backfilled with Selected excavated material

Pipe bedding materials shall comply with the standard details as shown on drawings and with the following requirements:

Sand Cement Bedding and Surround

Sand cement bedding and surround shall be a mixture of sand cement (200 kg cement to 1m³ of sand). Sand shall be natural well graded sand having hard, strong, durable particles. It shall be clean and free from extraneous materials, clay balls, organic matter or other detrimental material. The amount of fines passing sieve No. 200 shall not exceed 15 percent.

Granular Bedding

Granular material for granular bedding shall be composed of crushed rock aggregates of 14mm maximum size natural, free from dirt, clay, roots, organics and other deleterious material. Lay and compact to the thickness shown on the Drawings over the full width of the trench. Scoop out suitable holes for the sockets and couplings and lay pipes. Adjust to exact line and level.

After testing and acceptance by the Engineer, backfill with a protective cushion of selected fill compacted by hand in layers not exceeding 150mm to a level not less than 300 mm above crown of pipe.

Concrete Bedding

For pipe to be laid on a concrete bed, concrete shall have a strength of 140 kgf/cm². Bedding arc/angle and thickness of concrete shall be as shown on Drawings.

Trench shall be excavated up to proposed concrete bed bottom level. Pipe shall be laid in the trench on designed slope and alignment and concrete support. Concrete shall be laid up to the desired bedding shape. Care shall be taken not to disturb the pipe alignment while laying and compacting the concrete underneath the pipe.

After testing and acceptance by the Engineer, backfill with a protective cushion of selected fill compacted by hand in layers not exceeding 150mm to a level not less than 300 mm above crown of pipe.

Concrete Encasement

Where the superimposed loads on the pipe due to backfill loads and/or traffic loads are so high that the desired bedding factor cannot be achieved by any other type of bedding, the pipes shall be surrounded by concrete as shown on the Drawings.

Excavation of the trench shall be done up to the proposed bottom of concrete encasement. Pipes shall be laid and jointed in the designed grade and alignment having precast concrete supports underneath, minimum of two supports for each pipe piece. Concrete shall be laid as shown on the Drawings, in a minimum of two layers to avoid buoyancy of pipes in concrete. The first layer of concrete shall cover the pipe up to the DN/4. Second layer may be laid after 24 hours so that first layer has hardened adequately and developed a proper bond with the

bottom of the pipe to prevent it from floating when the second layer of concrete is laid and compacted.

Flexibility of the pipeline shall be maintained by providing polystyrene or styropore, or similar flexible boards on the joint as shown on the Drawings. Utmost care shall be taken to keep the trench completely free from groundwater until the concrete has hardened sufficiently.

On passing onto sand embedment at each end of a concrete embedment or at each face of a concrete structure, a short pipe of length equal to 2 to 2.5 times the nominal pipe diameter shall be provided having a fully flexible joint at each end. The nearer joint shall be not more than 300mm from the concrete face.

Pipe Bedding in Rock Excavation

Bedding in rock excavation shall be as shown on Drawings. Selected sand fill shall be as specified to 300mm minimum above the crown of pipe.

903.06 Unstable Subsurface Conditions

Where soil is completely unstable and large settlements in the pipeline are expected and where deemed necessary, special arrangements as listed below should be made after proper site investigation and structural calculations.

- Improvement of mechanical properties of the soil
- Replacement of soil by other soil or concrete
- Pile foundations
- Reinforced concrete slab foundation

Where such conditions occur, a report shall be submitted to the Engineer, along with all the site data and Contractor's proposals for approval.

Where hard rock occurs in the bed just before or after compressible soft bed, it is desirable to provide a flexible joint at the junction of two materials to allow rotation of pipe pieces without damage in case of settlement of the soft bed as shown on drawings. In the case of pipelines laid under the slope of an embankment, any longitudinal tensile or bedding stress occurring in the pipe shall be taken into account.

903.07 Interconnection Between Existing and New Work

All interconnections between existing and new work shall be constructed by the Contractor in a manner that ensures the safety, structural adequacy and watertightness of the interface and the proper performance of the system.

903.08 Overpumping of Existing Sewage Flow

Where live sanitary sewers and appurtenances are to be demolished or replaced, the Contractor shall, in accordance with procedures accepted by the Engineer and prior to interruption of the existing sewage flow, implement measures for temporary overpumping

and dealing with such flow. Details of the Contractor's proposed measures, procedures and equipment shall be submitted to the Engineer for agreement before any existing live sewer is removed.

903.09 Construction of Manholes

Manholes shall be constructed of sulfate resisting in-situ reinforced concrete to the level, dimensions and shapes shown on the Drawings.

Benching to the manholes shall be in concrete as shown and detailed on drawings. "U" channels shall be formed with bottoms flush with the inside surfaces of pipes and the sides of the channels shall extend to the full height of the largest pipe and then sloped back at a minimum fall of ten percent. The benching and channels shall have a smooth steel trowelled finish. The finished diameter of channels shall be as the diameter of incoming and outgoing pipes. Branch channels shall be formed in the same manner as the main channels and streamlined in accordance with the details shown on the Drawings.

Ladders, safety chains and platforms shall be installed as shown on the Drawings and fixed to walls in an approved manner.

Manholes frames and covers shall be placed immediately after the construction of the manhole or structure. The frame shall be fixed in position and embedded in concrete or in non-shrink mortar as shown on the Drawings and as directed or approved. Covers shall be greased on the surfaces in contact with the frames.

Where pipes are built into manhole walls, the pipes shall be set accurately to the required line and elevation and the joints between pipes and walls shall be completely watertight and in accordance with the details shown on the Drawings and specified.

903.10 Testing Sewers and Manholes

903.10.1 General - All sewer pipe lines shall be tested before being backfilled. The lines shall be tested in lengths between manholes or such shorter lengths as the Engineer may approve and in all cases the tests shall be applied in the presence and to the satisfaction of the Engineer.

The testing of pipelines will normally be carried out after the placing of the embedment to the lower 120 degrees of the pipe and before the remainder of the backfill.

Every pipeline subjected to a test shall comply with the following conditions:

- The pipeline and all concrete shall be perfectly clean and dry and the joints uncovered.
- The level of the ground water in the trench shall be maintained as low as possible and in every case below 30 cms from the pipe invert or more depending on the type of bedding.
- No formwork for additional concrete shall have been erected.

Air, smoke or water shall be used to test the pipelines, as detailed for each type of pipe, but the Engineer reserves the right to direct the Contractor to test any particular length by any of

the specified methods, where circumstances in his opinion so require and the Contractor shall comply with such directions and shall make no charge for so doing.

No brackish/sea water shall be used for testing of pipelines.

The Contractor shall at his own expense provide ample expanding stoppers for each diameter of pipe to be laid, together with such upstand tubes, U-tubes, pumps and all other required testing apparatus to the approval of the Engineer.

The costs of supplying water and subsequently disposing of it in an approved manner shall be borne by the Contractor. Ground water may not be used for testing pipelines. The Contractor shall be responsible for adequately strutting stoppers when pipelines are subjected to a water test and shall take adequate precautions to ensure against any stopper or strutting being carried into a downstream pipe when the water is released.

903.10.2 Air Test for Gravity Lines - Air shall be pumped into the line by suitable means until a stable pressure of 100 mm head of water is indicated in a U-tube connected to the system. Air pressure shall not fall to less than 75 mm head of water during a period of 5 minutes without further pumping, after an initial period to allow stabilization.

903.10.3 Water Test for Gravity Lines - Prior to acceptance, all gravity pipes laid at the site shall be tested at a pressure of 0.8 Kg/cm² minimum to ascertain the workability of the joints. This test shall continue regularly and shall follow the pipe laying closely so that any corrections or replacements can be done prior to backfilling and without delay.

Before filling the pipe with water for testing, it shall be ensured that all thrust blocks and backfilling above the pipe to a depth equal to the pipe diameter, but leaving joints exposed for inspection have been completed. Pipe shall be filled slowly with potable water allowing air to escape through vents specially fixed for this purpose. A pressure gauge shall be fixed at the highest point in the line or shall be calibrated to read pressure at that Point. Test shall usually commence after one hour of filling the pipe, or as decided by the Engineer.

Pressure in the line shall be increased gradually to prevent any damage to the pipeline. Water shall be added at 10-minute intervals to maintain specified test pressure. If water so added during 30 minutes does not exceed 0.10 liter/hr/mm diameter of pipe for a pipe length of 100 m and also if there are no visible leakages of water, the pipe line shall be passed.

903.10.4 Water Test for Pressure Lines - All pressure lines shall be tested as follows: Fill line with water and allow for bleeding of entrapped air and 24 hours absorption period for the case of absorbent pipes. Pressurize the line to a pressure of 18 kg/cm² at its lower end. The test period shall not be less than 2 hours. The allowable leakage shall not exceed 0.1 litres per mm diameter per kilometer length per day per 30 meters of applied pressure. Additionally no visible leaks shall be detected in the line irrespective of the allowable leakage being met.

903.10.5 Infiltration Test for Gravity Lines: After backfill, plug ends and measure any infiltration into the line by approved methods. For pipe less than 700 mm diameter, infiltration shall not exceed 80 cc per hour per 100 meter length per mm of pipe diameter. For

pipes over 700 mm diameter infiltration shall not exceed 160 cc per hour per 100 meter length per mm of pipe diameter.

903.10.6 Mandrel Test - All pipelines less than 350 mm diameter, excluding pressure lines, shall be checked by drawing through each completed length of pipe a cylindrical mandrel of a diameter 10 mm less than the internal pipe diameter and a length not less than 300 mm.

903.10.7 Visual Tests - All pipelines shall be visually tested by methods approved by the Engineer. This shall include external visual inspection and internal inspection by mirrors or other approved methods.

903.10.8 Test Sections - Pipe lines shall be tested in sections approved by the Engineer. Test shall be carried out in the presence of the Engineer or his delegate. Air or water tests of gravity and pressure lines shall be carried out during construction and repeated before handing-over as required by the Engineer.

903.10.9 Failure to Meet Tests Requirements - Pipelines failing the prescribed tests requirements shall be rejected and the Contractor shall propose for the Engineer's approval remedial measures he intends to take. Failed sections shall be retested after the remedial measures are implemented until the test requirements are met to the satisfaction of the Engineer.

903.10.10 Manhole Testing - Water testing shall be carried out by the Contractor by filling the structure with water after plugging all inlets and outlets. The water shall be allowed to stand for 24 hours after which the water shall be refilled and allowed to stand for a further 24 hours test period during which the allowable leakage shall not exceed 1% of the total volume tested per 24 hours.

903.10.11 Re-testing - If the Engineer should suspect that a pipeline has been damaged during concreting or back-filling or subsequently he may order the Contractor to retest the suspected length by one of the approved methods. Should the retest indicate that the line is no longer capable of withstanding the prescribed tests, the Contractor shall forthwith search for and repair the damage and retest the pipe line until a satisfactory test is obtained and all costs incurred, including those of the retest, shall be borne by the Contractor.

Should it be found on completion of any particular section of the work that there is a rate of infiltration into the sewage system in that section in excess of 1 liter per hour per meter of internal diameter per linear meter of pipe, the Contractor shall at his own expense search for, isolate, repair and retest the defective lengths of pipe all to the satisfaction of the Engineer.

903.11 Thrust Blocks and Pipe Anchorages

Thrust blocks and pipe anchorages shall be constructed on all pressure mains at each change of direction and wherever a toe junction or blank end is constructed. Thrust Blocks shall be constructed of Class B28 concrete.

903.12 Puddle Flanges

Unless otherwise shown on the Drawings, all iron pipes passing through concrete walls or other similar structures shall incorporate a puddle flange. Such flanges shall be of the same dimensions as flanges for the size and class of pipe to which they are attached and the cost thereof shall be included by the Contractor in the appropriate items of the Bills of Quantities.

903.13 Opening in Constructional Work

Wherever possible, all pipes passing through walls and floors shall be built in as the work proceeds.

All holes or openings for pipes or other things passing through walls, floors or other permanent work, shall be neatly and accurately cut or formed and any work disturbed shall be made good at the Contractor's expense and to the approval of the Engineer.

All bolt holes or other openings required for securing machinery or plant shall be carefully formed in the exact positions required. The Contractor shall be responsible for obtaining from the various manufacturers, exact details of all holes and securing bolts required and shall be responsible for all boxing-out and subsequently grouting-in or, where this procedure is deemed necessary by the Engineer for obtaining templates and subsequent building in of bolts etc. all at the Contractor's expense. The position of all holes shall be checked by the Engineer before concreting or grouting is commenced.

All bolt holes in exposed positions and near the edge of concrete structures shall be sealed. The cost of these and subsequent operations shall be included in the Contractor's rates.

903.14 Works to be Watertight and Testing of Works

The whole of the works and connections to the Works shall be constructed in a watertight condition and shall be so maintained for the period of the Contract. Should any leakage or weeping take place in any part of the works, the defects shall be rectified by the Contractor at his own expense and should the Engineer consider it necessary, any part of the works shall be tested with water to ensure that they have been so constructed and maintained. All weirs shall be tested with water to ensure that they have been accurately constructed to level.

903.15 Works to be Left Perfect

The whole of the Works shall be handed over at the expiration of the Period of Maintenance, in a thoroughly sound, substantial clean, trim and watertight condition.

903.16 Clearing Up

On completion of the Work, the Contractor shall at his own expense forthwith remove all plant, timber, waste and surplus and other materials and leave the Site in a clean and tidy condition.

904 – REHABILITATION OF SEWER PIPES AND SANITARY STRUCTURES

904.01 Safety in Sewers and Sanitary Structures

904.01.1 Scope of Work - The Contractor's attention is drawn to the hazards involved in working within sewers, manholes, pumping or lifting stations, and ancillary structures. It is not intended that this Section should be a comprehensive manual on safer procedures to be adopted in sewers, but merely a guide for the Contractor who shall be responsible for ensuring adequate precautions are taken by his workforce to safeguard against any accidents whatsoever while working in or adjacent to sewers, manholes or pumping stations.

The need for adequate protection for the general public in the vicinal of all excavations and other potentially dangerous areas related to this work is stressed.

Particular attention is drawn to the dangers of poisoning, asphyxiation, or explosion while working in or near or inspecting sewers, manholes, chambers, treatment units, pumping stations, or any confined space. The Contractor shall obtain appropriate safety equipment and acquaint all personnel with the dangers involved and precautions to be taken. The Contractor shall use the publication of the Institution of Civil Engineers, Safety in Sewers and at Sewage Works, as a basis for safety procedures to be adopted when working in dangerous environments.

904.01.2 Physical Injury - The Contractor shall safeguard his workforce against physical injury and ensure the use of safety equipment for persons working in sewer. Safes equipment includes but shall not be limited to the following:

- Safety helmet
- Safety boots with non-ferrous sledged soles
- Safety belt (strong, readily washable with non-ferrous attachments for life line) Gloves
- Overalls

904.01.3 Hazardous Gases And Liquids - The contractor shall safeguard his workforce against the dangers of toxic, asphyxia TORY, inflammable, or explosive gaseous conditions in manholes, sewers, and ancillary structures.

Each group of workers engaged in working in sewer, manholes, pumping stations and ancillary structures shall be provided and be familiar with the operation of reputable gas testing equipment suitable for checking hydrogen sulphide, combustible gases, and lack of oxygen.

In addition, each group working in sewers shall have with them the following items:

- Lifting harness
- 4 Nos. 15 m lifelines with spring, shackle one end, eye at other
- Ladder
- Lifting frame complete with ropes and shackles for hand operation
- Powerful hand lamp, with flameproof switch
- Ventilation blower together with portable generator and flexible trunk

- Positive pressure respiratory facemasks with associated portable compressor and air hoses
- Gas detectors

Before entering any manhole, sewer, chamber, or the like, the atmosphere shall be tested to ensure that there is no build up of hydrogen sulphide or combustible gases, nor a lack of oxygen within such structures.

If working in sewers where accumulations of sludge or silt occur, the Contractor's attention is drawn to the fact that, when disturbed, sludge may release toxic gases. Continuous monitoring shall be made while work is in progress in live sewers or structures containing sludge or silt.

Should anyone working in a manhole, sewer, or chamber complain of nausea or dizziness, all personnel shall be removed from that location. Work should resume only when it is safe to do so or with the use of breathing apparatus.

The Contractor shall identify prior to beginning work on a pipe section and inform his workforce of the hazards of inflammatory or otherwise noxious volatile liquids being discharged into sewers. Some of these may produce vapors, which can cause irritation to eyes, nose, and skin.

Should the presence of such liquids be suspected, immediate and suitable precautionary measures shall be taken.

904.01.4 Health Hazards - The Contractor shall safeguard his workforce against hazards to health when working in sewers. The Contractor shall inform his workmen of the dangers of bacterial infection while working in a Sewage contaminated environment and shall impress upon them the importance of personal hygiene. A mobile mess room with washing and changing facilities shall be provided by the Contractor for each working area.

All members of the workforce shall be fit and everyone who will be expected to work in sewers shall not suffer from any of the following:

- Any heart defect,
- Any history of fits or blackouts,
- Deafness or loss of balance
- Claustrophobia
- Recurrent back ailments
- Shortage of breathe on light exertion

All members of the workforce shall be vaccinated against tetanus, typhoid, paratyphoid and cholera, and shall carry up-to-date medical records on their person. The Contractor shall provide a medical certificate of fitness for all personnel.

904.01.5 Mobile Office Equipment - The Contractor shall keep installed within easy access of each working group, emergency equipment that shall include, but shall not be limited to the following:

- Barrier cream

- Disinfectant
- First aid kit with eye bath
- Stretcher
- 15 m long lifelines with spring shackle one end, eye at other
- Lifting harnesses
- Breathing apparatus with air bottle - 2 sets

The address and telephone number of the nearest hospital with emergency facilities shall be posted in area such as mess rooms.

The Contractor shall be solely responsible for liability for any claim or legal action arising as a result of an accident and shall not be absolved of any liability under the Contract for his having conformed with the above requirements

904.01.6 Safety Officer - The Contractor shall appoint a Safety officer who shall be responsible for ensuring that the Contractor's employees follow the safer procedures, specified above, and that they are supplied with the basic equipment as detailed.

The Safety officer shall ensure that at least one person in each group shall be instructed in rescue procedures, resuscitation techniques, basic first-aid, and the use of gas detection apparatus.

904.01.7 Safety of The Public - The Contractor shall provide safety barriers as specified to be erected around all unattended open trenches or open manholes. Suitable temporary steel sheet covers may be used where deemed necessary.

Whenever the Contractor's workforce leaves the site of the works, all manhole covers shall be replaced or covered properly with steel covers.

The Contractor shall provide traffic signs, which shall be erected in the roadway at the ends of the length of sewer being worked on whenever it is intended to use heavy vehicles or traverse the road with temporary pipework or any other items, which may cause an obstruction to traffic. The signs shall have "MEN AT WORK" written in Arabic and English to the approval of the Engineer. All other requirements of "Maintenance and Protection of Traffic" Section shall apply.

904.02 Over Pumping and Flow Diversion

904.02.1 Scope of Work - Where work in existing sewers and manholes is required by the contract, the Contractor shall maintain sewage flow arising from whatsoever source, and shall prevent any flow from entering the sewer being worked on during any phase of the execution of the Works. The Contractor shall submit his proposed method of over pumping or flow diversion to the Engineer for approval prior to the start of construction. The proposed method shall include proposed alignments and design requirements of the discharge pressure pipe to the terminal point.

The Contractor shall furnish, install, and operate pumps, plugs, conduits, and other equipment required to divert flow around the pipe segment upon which work is to be performed. Sewage shall not be allowed to flow into gutters, streets, or over sidewalks. After the work on the

sewers has been completed, tested, and accepted by the Engineer, flow shall be restored to normal.

904.02.2 Pipe Stoppers - The flow shall be plugged off using an approved type of mechanical pipe stopper having a circumferential compressible rubber ring, the stopper being fully inserted inside the pipe before tightening up. Suitable inflatable stoppers may be approved for small diameter sewers. Stopper shall be of the most sophisticated and reliable type available in the Market.

904.02.2.1 Stopping off flow - For work on any length of sewer, the Contractor shall plug off any number of inlets to the upstream manhole as required. The next manhole upstream shall be used as a pumping sump with the outlet to that manhole also being plugged. Where there is a possibility of sewage backup from downstream, the outlet to the downstream manhole shall also be plugged. Additional stoppers shall be used as necessary to ensure safe working conditions.

All house connections that discharge into temporarily plugged sewers are to be stopped off and a pre-approved system of over pumping shall be installed.

904.02.3 Pumping Equipment - Over pumping shall be carried out from one manhole to another located downstream. The pumping system shall be of sufficient capacity to handle peak existing flow.

Pumping shall be done by the Contractor in such a manner that no damage to public or private property results, and no nuisance or public health problem is created. The pumped sewage shall be in an enclosed hose or pipe that is free of all leaks and shall be reinserted into the sewer system.

The Contractor shall verify the peak average flows ahead of time and he shall design his pumping system accordingly. The Contractor shall submit his design for the Engineer's review.

All pumping units shall be electric driven unless otherwise approved by the Engineer. All pumping units shall be supplied with a control panel, which shall show the status of pumps in operation at all times. Such control panel shall be submitted to the Engineer for approval.

904.02.3.1 Submersible Portable Pump - A submersible electrically driven, non-clog sewage pump shall be installed in the manhole. It shall be capable of handling all the required sewage flow and any likely material transported to the host manhole. The pump shall be slender capable of passing through the manhole cover (600 mm diameter).

The bottom side of the pump, i.e. suction inlet, shall be connected to a suction stand constructed of cast iron or protected steel and resting on the manhole bottom. The discharge side of the pump shall be connected to the external pipe as specified hereinafter in this Section by means of a flexible hose or other material as deemed appropriate.

The pump shall be controlled by float switches installed to operate at levels pre-approved by the Engineer.

904.02.3.2 Suction Lift Pump - In areas where the submersible pump described above is not sufficient to handle the existing flow, the contractor may use one or more suction lift pumps installed temporarily on the street level with suction hose(s) leading into one or more manholes as necessary. The pumps shall be centrifugal of a special design suitable to this work. The pump(s) shall discharge the sewage into the external pipes. The pumps shall be electrically driven with sufficient lift capacity in the suction side.

The noise level shall be kept to a minimum in accordance with these Specifications. When used for power generation, internal combustion engines shall include proper and adequate means to reduce excessive noise levels.

904.02.3.3 Power Generation - The Contractor shall make his own arrangements to provide power to the site for running the pumping equipment. If mobile power generators are used, then noise level shall be kept to a minimum in accordance with these specifications.

904.02.4 Soundproofing - The Contractor shall take special measures to alleviate and contain within acceptable limits the nuisance associated with the use and operation of the pumping equipment and generators and all other machines and machinery which generate unacceptable noise levels under normal service conditions. Suitable additional silencers and noise limiting enclosures must be provided for the equipment. Before commencing any work, the contractor shall submit his proposals for limiting the noise generated to the Engineer for approval. The granting of approval will not in any way relieve the Contractor of his obligations under the Conditions of Contract.

904.02.5 Watching And Standby Facilities - Full redundancy stand-by facilities of both pumps and generators shall be maintained at the site for use at short notice in the event of failure of other equipment in use.

Constant full time 24-hour attendance shall be provided at each pumping location such that, in the event of mechanical breakdown, immediate assistance is summoned. The cost of damages (if any), due to the Contractor's default, to private or state property will be the sole responsibility of the Contractor.

In certain circumstances, during periods of low flow, the Engineer may give approval for the pump and generator to be intermittently switched off.

Depending upon the magnitude of the flow arising in small diameter reticulation sewers, the Engineer may give approval to the periodic use of a vacuum tanker or cesspit emptier to remove sewage from the pipeline in lieu of pumping. Approval for such a measure may be withdrawn by the Engineer at any time.

904.02.6 Over Pumping or Flow - To bypass a length of sewer undergoing replacement or renovation work, the flow of sewage shall be over pumped and discharged into a downstream manhole on the sewer line. Subject to the Contractor obtaining the necessary approval from the Engineer, the sewage may be over pumped by utilizing an adjacent surface water drain where it is impractical to use the sewer system. It must be clearly demonstrated by the Contractor that no sewer is available for the diversion of the flow before proposing to use storm drain lines for diversion of the sewage. In such a case, the sewage

flow shall be returned to the sewerage network at a suitable point downstream of the work in progress.

The open end of the pump discharge pipe shall be laid so as to minimize turbulence of the pumped flow into the sewer system.

Upon completion of over pumping, the Contractor shall carry out sewer, or storm drain when utilized, cleaning by jetting, flushing or any other means required to return the pipes to serviceable condition to the satisfaction of the Engineer.

Upon completion of all works, the Contractor shall be responsible for ensuring that the sewerage system is clean, free from blockages, and free flowing. The Contractor shall employ any means necessary to ensure that the system is fit and in a serviceable condition.

904.02.7 Temporary Diversion of Flow - Where the Contractor considers it necessary for the expediency of the Works, the temporary diversion of a sewer by discharging the pumped flow into another branch or main sewer, whether connected or not, may be allowed. The Contractor should notify the Engineer of his intentions and submit his proposals before the implementation of any such diversion to ensure that the receiving sewer is capable of handling the additional flow.

The Contractor shall give full details of pipe diameter, route, and levels in proposals for temporary diversions, subject to the Engineer's approval, and shall be totally responsible for obtaining all other permissions and approvals relevant to any flow diversions.

All diversionary works shall be subject to the requirements of the Contract as if they formed part of the Permanent Works.

904.02.8 Prevention of Unpleasant Odors - The Contractor shall take all necessary precautions and measures to prevent the spread of unpleasant odors. This shall include, if necessary, chemical treatment of the sewage in order to increase the pH and thus reduce the stripping off H₂S gas or use chemicals to oxidize and precipitate the sulfides in the liquid phase. It shall also include means to draw the air in confined odor producing areas and pass it to mobile scrubbing units.

904.03 Sewer Pipeline and Manhole Cleaning

904.03.1 Scope of Work - This Section covers sewer pipeline and manhole cleaning to be carried out on all sewers and manholes as deemed necessary for the execution of the Works. The Contractor should note that the success of any renovation operations depends upon the line being properly cleaned.

904.03.2 Safety - Before carrying out any cleaning operations, due regard shall be given to the safety precautions required in "Safety in Sewers and Sanitary Structures" Section.

904.03.3 Scope of Operations - Sewer and manhole cleaning is intended to include, but is not limited to, the following work:

- Establishing the location of manholes and removal of overburden.

- Removing of mud buckets and disposal of the contents.
- Cleaning of manholes with water jetting or steam jetting, wire brushing, or other approved means.
- Removing of any sand and debris from manhole bases and beaching.
- Plugging flows and over pumping
- Bucket and winch dredging or any other necessary cleaning process
- Flushing with water
- Removing of all sand and debris jetted or dredged from the sewers and disposal of same to an approved location

904.03.4 Extent of Cleaning - Cleaning of sewers and manholes prior to CCTV inspection, if requested by the Engineer, shall include any or all of the above operations. The Contractor should note that sewers and manholes may have substantial deposits of sand, sediment, pieces of wires or steel bars, and debris due to wind action, construction works, illegal tipping, and the like. The Contractor shall allow for clearing of all such material and disposing of the same to an approved location.

All cleaning shall be thorough and shall include all operations necessary to remove all grease, sediments, slime, and loose concrete from the walls, underside of the roof slab and beaching of manholes, and the removable of all sand, silt, grease, rocks, sediments, debris obstructions and other materials from within the sewer, and all loose, flaky or all soft corroded pipe wall material. The use of water jetting, wire brushes, egg beaters, scrapers, or any other suitable equipment may be necessary to prepare the sewer line and manholes for renovation. The application of such devices may be monitored by CCTV to prevent any damage to the pipe if requested by the Engineer.

For cast iron junction pieces that are to remain in the renovated sewer, the Contractor shall ream out or grind off the corrosion products to produce a pipe of diameter equal to the adjacent pipes. Care shall be taken to grind off all burrs that may otherwise puncture lining tubes during the renovation works.

904.03.5 Cleaning Precautions - During sewer cleaning all reasonable precautions shall be taken in the use of cleaning equipment to prevent damage to pipes or the flooding of public or private property.

904.03.6 Equipment - Sewers shall be cleaned using a high velocity water jet equipment, and mechanically or hydraulically propelled equipment approved by the Engineer. The selection of the equipment used shall be based on the conditions of the lines at the time work commences and shall be to the approval of the Engineer. The equipment shall be capable of removing dirt, grease, rocks, concrete blocks, steel bars, sand, corrosion products, debris, and other materials, or obstructions removable by proper cleaning equipment.

904.03.6.1 Vacuum Tankers - Vacuum tankers shall have a minimum capacity of 15,000 liters suitable to the requirements and location of the project. The tanker shall be mounted on a suitable diesel tractor unit and chassis. The tank must be suitable for the suction of viscous effluent, sand, and all other debris, through a hose by means of a vacuum created inside the tank.

The vacuum system shall be adequate to handle solids, liquids or mixture of both for sufficient operation from the deepest manhole and with a minimum hose diameter not less than six inches.

Evacuation of the tank shall be accomplished by pressurization of the tank, by gravity, or by tipping the tank. The tank shall be fabricated from mild steel and contain a minimum of 3 baffles.

A full-sized rear door shall be provided with a mechanical interlock for safe operation, and two sight domes with easy removal for cleaning.

A water-cooled vacuum pump shall be provided with two cut-out valves. One primary valve and one secondary valve shall protect the pump from ingress of effluence. The pump shall be of adequate capacity to effect suction of debris from the deepest manhole.

Additional equipment shall include a front end tipping gear and hydraulic valves to control vacuum pump, hydraulic tipping and rear door.

Fittings and accessories shall be provided as necessary to ensure proper and safe operation of the tanker

904.03.6.2 Jetting Tankers - The jetting tankers shall have a minimum capacity of 15,000 liters suitable to the requirements and location of the project. The tanker shall be mounted on a diesel tractor unit and chassis, manufactured for sewer cleaning.

The jetting vehicle shall have the capability to vary the water pressure produced at the jetting nozzle up to 170 bars and be equipped with a sufficient leash of suitable 25 mm bore hose to allow passage of the nozzle through any sewer length. The water flow at 100 bars shall be not less than 2.5 liters per second.

Accessories and fittings shall be provided as needed for the proper and safe operation of the tanker.

The nozzle shape shall be of such configuration to be able to handle the type of sand, debris and cleaning of pipe walls in the best appropriate manner, as approved by the Engineer.

904.03.6.3 Catalogues - The Contractor shall supply the Engineer with catalogues and technical data of the equipment proposed for use in sewer line cleaning prior to the commencement of the work for approval of the Engineer.

904.03.6.4 Combination Vacuum / Jetting Sewer Cleaning Equipment - At the Contractor's option and subject to the approval of the Engineer, the machinery used may be of double purpose built in models combining both the vacuum and jetting equipment on one truck chassis.

904.03.7 Material Removal - All sludge, dirt, sand, rocks, concrete blocks, steel bars grease, and other solid or semi-solid materials resulting from the cleaning operation shall be removed at the downstream manhole of the section being cleaned. Such material that causes

sewer line stoppages, accumulation of sand or debris in wet wells, or damage to pumping equipment shall not be permitted to flow through the sewer line down-stream.

The Contractor shall submit proposed methods for material removal primarily consisting of high-powered vacuum hosing to cleaning trucks with sufficient size and capacity to suit the project conditions. Stanking of the downstream manhole shall be applied in addition to vacuum hosing to ensure that no sand or debris is passed downstream. Stanking procedure shall be submitted for the approval of the Engineer.

904.03.8 Disposal of Material - All solids or semi-solids resulting from the cleaning operations shall be removed from the Site and shall be properly disposed of at approved dumping area/s no less frequently than at the end of each working day.

Where the Contractor uses vacuum tankers with decanting facilities for the collection of debris he shall under no circumstances discharge debris into any sewer or pumping station. All debris shall be taken to the approved location. Vacuum tankers shall be of adequate capacity to minimize time cost due to traveling between the Site and the disposal location.

904.03.9 Jetting Water - Brackish water may be used for general cleaning, but potable water must be used for the final cleaning prior to any renovation work

904.03.10 Bickering - All motorized vehicles and trailers shall be roadworthy and designed or modified specifically for the work involved. Bucket machines shall be in pairs with sufficient power to perform the work in an efficient manner. Machines shall be belt operated or have an overload device.

A range of bucket sizes shall be provided to suit the various pipe diameters. The buckets shall be cylindrical in cross section with boils at each end having center eye lugs. The buckets shall be of the clam shell type with the bottom made of two hinged halves such that when the bucket is pulled in the reverse direction, bottom first, the jaws open permitting debris to pass through. When the bucket is pulled forward, the jaws shall close thereby retaining any material in the bucket, which subsequently enters. Both ends of the bucket shall be able to dig into and scrape sediments and debris off the sewer invert, wet well bottoms, floors and walls. The buckets shall be equipped with at least six longitudinal runners attached to the outer surface and for the full length of the bucket. The runners shall taper in to the centerline of the bucket at an angle of 30 and shall extend 30 mm from the edge of the bucket and be such as to reduce the snagging at displaced joints.

904.03.11 Broken or Collapsed Pipes - The contractor shall establish emergency facilities to cover the possibility of pipe broken or collapse during his operations. These shall include, but are not limited to the following:

- Immediate over pumping using stand-by equipment.
- Dewatering equipment to be immediately available, where required.
- Excavation permits to be obtained in advance of work in any section.
- Replacement of the broken or collapsed pipe section of like material.
- Plant and labor to be available for emergency works.

The final cleaning shall be checked by CCTV survey, if it deems to be necessary by the Engineer, as specified in "CCTV inspection" Section, of these Specifications and shall be applicable to appropriate rate included in the Bill of Quantities. If the CCTV survey was requested due to negligence in the work, the contractor bears all the expenses.

The contractor shall notify the Engineer immediately about location of such damaged pipe and the Engineer shall determine the cause of this damage and instruct the Contractor of the measures to be taken accordingly.

904.04 CCTV Inspection

After the Contractor has completed the cleaning of the pipeline, a CCTV camera shall be passed through the line. The CCTV Survey will allow for:

- The detection of significant leaks, cracks, breaks, and joint failures.
- The presence of any pipe collapse
- The nature and overall conditions of the pipe

904.04.1 CCTV Survey of the Sewer Lines - In order to conduct a CCTV survey of the existing main sewer lines properly, it is necessary to clean the sewer lines prior to conduct the CCTV survey to allow for proper inspection inside the sewer lines. The clean-up activities will entail:

- Removal of any debris materials inside the sewer line by running a special brush inside the line section, using a special winch.
- Flushing of the sewer lines using a tanker truck to remove any remnants and to clean the sidewall of the sewer pipes to allow for proper inspection of the pipe during the survey, if necessary.

Upon completing clean-up activities, the CCTV survey will be conducted on each section of the lines.

The CCTV survey will be performed with a Colored Video Camera system manufactured for working inside the pipes. The Video Camera shall be mounted on an adaptable trolley that allows the inspection of pipes of nominal diameter that ranges between 200 mm to more than 800 mm.

The Video Camera should be able to show either a horizontal view of the pipe or side views using a special lighting system.

The survey system shall be also equipped with a counter to allow for continuous display of footage on the video film that is instantly displayed on a color monitor during the survey.

Photographic pictures of the critical sections shall be taken and included in the reports. The repairs recommended in the technical report of the Contractor.

904.04.2 Report Preparation - Upon completion of the CCTV survey, a report that presents the results of the survey shall be prepared. The report shall include:

- 1) A detailed description of the various methodologies used for the performance of the clean up activities.
- 2) A detailed description of all the debris removed from the sewer lines, if any.
- 3) An assessment of the condition of each manhole.
- 4) An assessment of the condition of each section of the sewer lines including size and length of sections, and presence of leaks, fractures, joint failures, and pipe collapses. The exact location of any deficiencies encountered will be indicated.

The report of the cleaning, and the CCTV survey activities shall be submitted with videotapes and shall be accompanied by color photographs that highlight the major deficiencies found in the various sections of the sewer lines. The report shall be presented in table format, along with all technical recommendations regarding the rehabilitation or the replacement of each pipe section or manhole.

The videotapes recorded during the survey and provided with the report shall be labeled with the name of the project, the section labels, the length of each section surveyed, and the date of survey.

Upon completion of all repairs at different sections of the pipes or any part of the previously surveyed pipeline, and if it deems to be necessary by the Engineer, the video camera inspection may be requested to insure that the repairs have been done properly according to the technical recommendation.

904.05 Renovation Work for Existing Manholes

904.05.1 Scope of Work - This Section covers work particular to renovation works for existing sanitary manholes, inspection chambers, gullies and drainage channels including cover and slab sealing or replacement, GRP lining installation, concrete wall encasement (from inside or outside) and beaching improvements. This work provides for all aspects of manhole renovation including the type of repair, methods of repair, and equipment.

The contractor, prior to any renovation works, shall submit to the Engineer for approval a complete descriptive method statement, materials along with all related shop drawings necessary for completing the work(s).

The Contractor shall also direct his attention to all conditions required in "Safety in Sewers and Sanitary Structures" which shall be met when performing work under this Section.

904.05.2 Materials

904.05.2.1 Environmental Conditions - All the materials and equipment proposed for installation as part of the sanitary sewer network shall be capable of withstanding the environmental conditions likely to be encountered.

904.05.2.2 Samples - Immediately after award of the Contract, the Contractor shall submit to the Engineer for approval a list of manufacturer from whom materials will be purchased for the Works. If required by the Engineer, the Contractor shall deliver samples of the materials to the office of the Engineer, or nominated testing laboratories.

Any materials not approved, or failing to comply with the approved samples shall immediately be removed from the Site.

904.05.2.3 Epoxy Mortar - Epoxy mortar shall be a mixture of silica aggregates and two-component epoxy resin and hardened, and shall be free from any solvent. The two-component epoxy changes to a gel upon mixing and, together with the chemically-resistant aggregate, forms a thixotropic mix for easy application by trowel to floors, walls, and stairs. The epoxy mortar shall have enough flexibility to bridge minor cracks and shall have good adhesion to dry and damp concrete surfaces. Primer and sealing coats for the epoxy mortar layer shall be as recommended by the manufacturer.

The epoxy mortar shall have an excellent resistance to a wide range of chemicals prevalent in the sewage at the temperature of 40 degrees C. such as bleach, detergents, sodium chloride solution (20%) and sodium hydroxide (20%), sulfuric acid solution 17% w/w. Change of weight shall not exceed 5%.

The epoxy mortar shall be supplied in sealed containers marked at the factory with the date of manufacture. Any material that has exceeded the recommended shelf life shall not be used.

The epoxy mortar shall be handled, stored, and used in strict accordance with the manufacturer's instructions and to the satisfaction of the Engineer.

The Contractor shall demonstrate the use of the material on site before approval will be given. The Contractor shall also have the material tested and certified in an independent laboratory by running tests on the samples to ensure that the material complied with the Specifications. All tests shall be performed at 23°C and 40°C temperatures.

The material shall have the following properties:

- | | |
|---|--------------------------|
| - Tensile Strength per ASTM C 307 at 7 days | > 5 N/mm ² |
| - Compressive Strength per ASTM C 579 at 7 days | > 60 N/mm ² |
| - Flexural Strength per ASTM C 580 at 7 days | > 28 N/mm ² |
| - Modules of Elasticity at 7 days ASTM C580 | < 8000 N/mm ² |
| - Water Absorption per ASTM C 413 | <3% |
| - Bond Strength to Brick Damp and Wet ASTM C321 | > 1.5 N/mm ² |

Chemical resistance per ASTM C 267:

After immersion for 100days in 17% w/w solution of sulphuric acid at 23 °C

- | | |
|--------------------------------|-----|
| - Change in weight | <5% |
| - Loss of compressive strength | <7% |

After immersion for 100 days in 17% w/w solution of sulphuric acid at 40 °C

- | | |
|--------------------------------|------|
| - Change in weight | <5% |
| - Loss in compressive strength | <20% |

The test specimen, 3 sets for each test, shall remain sound after acid immersion and shall not exhibit any surface cracking, etching, pitting, softening of the exposed surface, or changing in color.

904.05.2.4 Sand-Cement Grout - Sand-cement grout 3:1 for use in manhole renovation shall be made using Type V Portland cement with the minimum amount of water to give the required degree of fluidity.

904.05.2.5 Concrete Works - Concrete Works including materials and construction requirements, etc. shall be in accordance with the "Concrete" Sections of the Specifications.

904.05.2.6 Covers and Frames - Cast iron and frames shall be as specified and approved by the Engineer.

904.05.3 Workmanship - Manholes requiring renovation shall be as shown on the drawings or as directed by the Engineer.

The applicable clauses of "Manholes, Handholes, Chambers, etc" and "Structural Excavation and Backfill" Sections of these Specifications shall also apply.

904.05.3.1 Preparatory Work - Prior to renovation work being carried out on manholes, the manholes shall have been cleaned as specified in "Sewer and Manhole Cleaning" Section.

Over pumping and flow diversion shall be carried out where necessary to complete the work as specified in this Section.

904.05.3.2 Painting of Manhole Cover and Frame - Where required, the existing Cast Iron cover must be removed and both, the cover and the exposed part of the frame must be cleaned, wire brushed, and sand blasted in order to remove all scale and rust.

Protection painting shall then be applied and shall consist of three (3) coats of approved coal tar epoxy. The total dry film thickness shall not be less than 0.4 mm.

904.05.3.3 Replacement of Manhole Cover and Frame - Where required, the existing manhole cover and frame shall be disposed of as directed by the Engineer and a new heavy duty Cast Iron cover Class D 400 to BS EN 124, with circular or rectangular frame base to suit the existing opening, must be provided as specified elsewhere in this section.

904.05.3.4 Sealing of Concrete Cover Slab - The existing cover slab shall be removed and the bottom of the cover slab shall be cleaned by jetting, brushing, or chipping to remove loose concrete and debris, and then sand blasted to remove surface laitance. Exposed reinforcement shall be cleaned from rust by sand blasting. The bottom of the slab shall then be given a minimum layer of 12 mm thickness epoxy mortar.

Where necessary, the top level of the manhole wall shall be adjusted in height. The cover slab shall be placed on a layer of mortar to adjust level accordingly.

The surface area around the cover slab shall be restored in accordance "Surface Restoration" Section. Excavations shall be as required in Clause 901 of this section.

904.05.3.5 Replacement of Concrete Cover Slab - The cover slab shall be removed. Manhole cover and frame shall be removed from cover slab and cleaned, sand blasted, given two coats of the approved coal tar compound and transported to an approved storage area. The top of manhole walls shall be prepared to receive and seat properly the new cover slab. Where required, the top level of manhole walls shall be adjusted. A new precast reinforced concrete slab, fitted with a new heavy-duty cast iron cover and frame shall then be installed. The lower face of the slab shall be coated with coal tar epoxy. The surface around the manhole cover slab shall be reinstated.

904.05.3.6 Raising Manhole Walls to Grade - Where top of the manhole walls must be adjusted in order to have the cover level matching with the finished grade level, cover slab shall be removed, as appropriate. The top of walls shall then be shaped to receive the existing or new cover slab. The cover slab shall be installed on a mortar bed and reinstatement carried out, and all works finished to the approval of the Engineer.

The Contractor shall break up any adjusting bricks, chip the manhole ring to required level or raise the manhole wall to required level by pouring an in-situ additional ring as shown on the Drawings. For height adjustments in excess of 30 cm, the Contractor may use precast concrete rings.

904.05.3.7 Raising and lowering of Manhole Cover - The rate shall include saw cutting the existing asphalt layer, where applicable, excavate around the manhole to the ceiling level, demolishing of the access shaft, remove, clean, paint, and reinstall the existing manhole cover and frame to the finished grade according to method of reinstallation the frame, whether embedded in the concrete ring base, precast or cast in situ, over an adjustable concrete bricks or cast in place with insisted part of the concrete access shaft. It shall also include the additional concrete ring around the reinstated access shaft.

The rate shall also include all manpower, equipment, materials and accessories necessary to complete the work as specified in the drawings, in accordance with the specifications and as directed by the Engineer.

904.05.3.8 Concrete Encasement - Where the manhole walls are found with tremendous cracks, deterioration in wall reinforcements and collapsed sections of the wall and where it is dangerous or inconvenient to work from inside the manhole or to disturb the sewage flow, concrete encasement around the manhole shall be applied.

The area around the manhole shall be excavated to provide enough space for formwork and safe working area. The contractor shall take all the necessary measures to secure the excavation area against any collapse and use a proper supporting system for the sides of the excavation.

The external walls of the existing manholes shall be thoroughly brushed and cleaned from any soil, dirt and sewage and where necessary use chisels to chip and remove all notches, debris or loose concrete prior to concrete encasement as shown on the drawings and to the satisfaction of the Engineer.

The excavation shall then be backfilled with an approved and suitable material for compaction and the surface shall be reinstated to the existing thicknesses of road pavement.

For manholes over 3 ms deep, a complete set of shop drawings with method statement shall be submitted to the Engineer for approval.

904.05.3.9 Miscellaneous Repairs - Work to correct minor manhole defects shall include:

- i. Scot Repair - Repair small areas (not to exceed 0.5 m x 0.5 m) of manhole walls by cleaning, breaking and removing corroded material, filling with epoxy mortar and trowelling smooth.
- ii. Open Joint Sealing - Where joints are not sealed between manhole rings, fill with epoxy mortar after cleaning to remove corroded material and trowel smooth.
- iii. House Connections - Where house connections pipes are deteriorated or protruding cut back and clean around the connection to remove loose or corroded material, fill holes with epoxy mortar and trowel smooth.
- iv. Replace Step Irons - Where step irons are unsafe and are not being removed as part of other manhole work, remove and replace by new one, break out existing step, fill void with epoxy mortar and trowel smooth.

905 – MEASUREMENT AND PAYMENT

905.01 Dismantling and Removal of Existing Pipes, Culverts and Channels

905.01.1 Measurement

- a. Dismantling and removal of existing pipes shall be measured in linear meter irrespective of type and diameter of pipe dismantled and removed.
- b. Breaking and dismantling of existing channels and culverts shall be measured by Cubic meter irrespective of the size of channels and culverts.

905.01.2 Payment

Payment for dismantling and removal of existing pipes, culverts and channels shall be at the rates indicated in the Bill of Quantities which rate shall include for all required materials, labors, tools, equipment, disposal of salvaged materials, replacement with backfilling materials and reinstatement of surfaces to same pre-existing conditions.

905.02 Excavation and Earthwork for Potable Water, Stormwater and Sewerage Networks

All excavations including excavation to reduce levels shall start from natural ground levels, as no measurement shall be carried out for removal of vegetable soil in the areas of trenches for potable water, stormwater and sewerage networks. Starting levels of excavations to be

carried out in areas already excavated and measured shall be the bottom level of such excavation previously measured.

Trench excavation for sanitary sewerage, stormwater and potable water lines, culverts and channels shall be measured in cubic meters stating the pipe size or dimensions of culverts and channels, and the average depth of trench defined below.

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.

The maximum width of trench to calculate the volume of trench excavation mentioned above shall be as follows:

- as stated in clause 901.10.3.1 of these Specifications for sewerage and stormwater networks.

- as stated in clause 901.10.3.2 of these Specifications for potable water networks.

Trenches to be used for more than one item, shall be so described stating the number and size of each utility within the trench.

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.

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.

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:

- Excavating in any type of ground, including structural fill, contaminated fill, clay or others, but excluding rock (as defined in the Specifications).
- Excavating by hand or machine.
- Dewatering operations necessary for keeping excavation free from water whether groundwater, sea water or any other sources.
- Leveling or grading and compacting bottom of excavations.
- All necessary double handling of excavated materials.
- Trimming or planking and strutting sides, bracing, driving steel sheeting or piling and any other temporary or permanent supports to sides of excavation.
- Selecting excavated materials, backfilling and compacting.
- Removal of 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 its subsequent re-transport back to the site.
- The additional excavation necessary to provide working space or shoring.

- Exposing by hand digging or special equipment, supporting, protecting and maintaining existing services and utilities.
- Providing and installation of warning tape.
- Making good all work disturbed.
- Temporary supports to roads or structure as required by the Engineer.
- 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.
- 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.
- Providing and operating all pump and pump stations for overpumping and flow diversion of sewage as specified.
- Reinstatement of all surfaces damaged by traffic due to the Works.

Excavation in rock, as defined in the Specifications, shall be included in the general excavation. It shall include all costs incurred in breaking up and removing rock by whatever means are necessary including use of compressed air operated breaking tools, drilling, wedging, sledging and the like.

All other types of excavations including excavation for structures, foundations, shall be measured in cubic meters. 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 not be measured. The volume of such excavations shall be computed as the product of the horizontal or plan area of the base or blinding layer, and the average depth from the starting level to the underside of the base or blinding layer.

All fill work to make up levels shall be measured net in cubic meters. Measured volume shall be based on the dimensions as shown on the drawings or ordered by the Engineer.

Fill work to make up levels using surplus excavated materials shall be measured separately to that using imported selected fill.

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.

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.

905.03 Surface Restoration (Included in “Section VI - ASPHALT WORKS”)

905.04 Pipework, pipe culverts, and Manholes

905.04.1 Pipework and Pipe culverts

Pipes and pipe culverts shall generally be measured net in linear meters over all fittings along the center line of pipe for each diameter and type separately. The length of pipe shall be measured net between the external faces of the structures at both ends.

Back drop pipes shall be measured in linear meters and quantities shall be added to the quantity of pipes of same size and type.

In addition to what is stated before in these preambles, or in the descriptions of the items, the rates of the pipes shall include wherever required for:

- Laying in trench at any depth,
- Calibrating and preparing ends for jointing and jointing materials.
- Coatings and linings whether done in the manufacture or on site.
- Providing any temporary or permanent supports, fixing brackets and accessories.
- Connecting pipes to manholes or pipes, including pipe sleeve or adapter if required or others, mortar, thrust blocks and making good.
- Temporary plugging ends.
- Additional works at backdrop pipes.
- Testing of pipelines in accordance with the Specifications.

For stormwater and sewerage networks, the rate inserted by the Contractor for pipeworks shall include the cost of providing and installation of all types of required fittings and accessories.

For potable water networks, all fittings, such as but not limited to, elbows, bends, tees, branches, couplings, flanges, gaskets, valves, joints, and the like shall be each enumerated. The rate for all fittings shall include materials, labors, equipment and all necessary items to complete the work.

Thrust blocks shall be measured by cubic meter. The rate for thrust blocks shall include materials, labors, equipment and all necessary items to complete the work.

905.04.2 Manholes, Reinforced Concrete Chambers, Service Boxes, and Fire Hydrant

-Manholes, reinforced concrete chambers, service boxes, fire hydrant, and inlets shall be enumerated stating the overall internal dimensions and the depth to underside of base slab in stages of one meter.

-Service Boxes and Fire Hydrants shall be enumerated.

The Contractor's rates shall be deemed to include for all labour, plant and materials necessary to construct the manholes complete, including earthworks (excavation and backfilling), all concrete works and blinding, reinforcement, formwork, water bars, benching, joints, admixtures and additives, sulphate resistant cement, surface treatment, waterproofing and coating, grading concrete bricks, internal steps or access ladders, medium and/or heavy duty manhole covers and frames, working around existing pipework and all other associated works complete.

905.04.3 Pipe Bedding and Surround

- Imported selected fill (crushed rock aggregates) for pipe bedding and surround of pipes shall be measured in linear meter. The rate shall include for materials, labors, equipment, water, spreading, laying and compaction to specified thicknesses.

- Concrete encasement for the bedding and surround of pipes shall be measured in linear meter.

In addition to what is stated above, the rates shall include for spreading and compacting to any depth.

The Contractor's rates for concrete encasement (beds and surrounds) shall include for the complete construction including, all labour and plant, concrete, formwork, reinforcement, fabric filter material, etc., and any additional excavation in the trench required for the bedding or surround. The rates for concrete beds and surrounds shall include for compressible impregnated fiberboard incorporated at pipe joints extending to full height and width of the concrete, and all concrete supports (minimum two per pipe length).

Any additional bedding requirements deemed necessary by the Engineer as a result of the maximum specified trench widths being exceeded by the Contractor shall be carried out at the Contractor's expense.

905.04.4 Utilities

The Contractor shall include in his rates for maintaining existing services in operation and all necessary works in connection with the protection and safety of adjacent structures and utilities and services, all as detailed under "Bill No.1 – General Requirements" or otherwise the cost of contractor for these items shall be considered included in the contractor's rate.

905.04.5 Temporary and Permanent Relocation, or Realignment of Existing Utilities

All temporary relocation and restoration of existing utilities necessary to facilitate execution of the works shall be measured in linear meter of relocated pipes, with replacement of old damaged pipes and materials shall also be measured in linear meter. The rates for these items shall allow for all work and the provision of materials including plugging flow and temporary works to maintain services in operation, excavation, disposal of excavated material,

upholding sides of excavation, keeping excavation free from water, protecting and supporting all existing utilities, dismantling pipe work, cables, and the like, laying new ones in position as per the requirements and Specifications of the various service authorities, reconnecting services into operation, testing, disinfecting, bedding, surrounding and backfilling in accordance with the requirements of the Specifications, and dismantling temporary works and making good all surfaces disturbed.

905.04.6 Safety in Sewers and Sanitary Structures

No separate payment shall be made for this item, the cost of which shall be deemed to be included in the rates for other work where safety procedures and equipment are required.

905.04.7 Sewer and Stormwater Pipeline and Manholes Cleaning

-Sewer pipeline cleaning shall be measured in linear meters stating the diameter of pipeline to be cleaned. Sewerage Manhole cleaning shall be enumerated stating the overall internal dimensions of the manhole to be cleaned.

- Stormwater System Cleaning and repair including pipelines and manholes shall be measured as lump sum.

Rates for sewer pipeline and manhole cleaning shall include for all cleaning works as required by the Specifications, all overpumping and flow diversion of existing sewage and disposal of all sludge, dirt, sand, rocks, grease and other solid or semi-solid materials resulting from the cleaning operations to an approved dumping area at the end of each working day.

905.04.8 CCTV Inspection

CCTV inspection of new and existing sewer pipelines shall be measured in linear meters.

Rates shall include for all the requirements of the relevant section of the Specifications.

Rates for CCTV inspection of existing sewer pipelines shall include for all necessary overpumping and flow diversion of existing sewage to allow inspection to proceed.

905.04.9 Repair of Existing Manholes and Culverts surfaces

Renovation works to existing manholes shall be measured per square meter of repaired areas.

Rates shall include for all the requirements of the relevant Section of the Specifications.

905.04.10 Overpumping and Flow Diversion

Payment for overpumping and flow diversion shall be measured per linear meter of pipelines diverted, including the furnishing and operation of pumps, soundproofing and noise control, the cost of which will be included in the rates for pipe laying, renovation work, construction of manholes or chambers, and associated work as appropriate. It shall include dealing with any flow arising from any source and all overpumping and flow diversion operation of the sewage flow including all plant and labour, pumps, pumping station pressure lines, power generators, stand by pumps, 24-hour attendant, and noise abatement for the duration of the Works.

The cost shall include all necessary protection measures for pressure lines from traffic either by raised, protective, steel covers or by actually excavating and burying lines in reservations, sidewalks, street crossings, all as approved by the Engineer. The work shall also cover all temporary structures needed to install the pumps, pumping stations and pressure lines. Also the work shall include for all excavation, backfilling and reinstatement of all surfaces damaged as a result of these operations.

905.04.11 Abandonment of Pipes and Manholes

The rates for grout filling of pipes on lines directed by the Engineer to be abandoned shall be paid for separately in accordance with the rate shown in the Bill of Quantities. Measurement shall be by the meter run for pipes measured by the horizontal distance between face of manholes.

905.04.12 Connections of Existing Sewers to New Manholes

Connections of existing sewers to new manholes shall be enumerated stating the type of pipe material, the applicable range of pipe diameters, and for any depth to invert of the existing pipe. Backdrop connections and level soffit connections shall be measured separately.

The Contractor's rates shall include for the programming of connection works to the approval of the Engineer, excavation in any type of ground including rock, excavation by hand or machine as directed by the Engineer, dewatering, supports to excavations, disposal of surplus excavated material to approved dumping sites, all necessary double handling of excavated materials, any additional excavation to provide working space, locating, exposing by hand digging or special equipment, supporting, protecting, working, around and maintaining existing services and utilities, overpumping and temporary diversion of sewage flows, breaking into existing sewers and making new connections including all new pipes and fittings, jointing and the like, bedding and surrounding new and existing pipes in accordance with the Engineer's instructions, blanking off or removing redundant pipework as directed by the Engineer, testing, backfilling excavations with approved materials, reinstatement of surfaces to match existing and all necessary labour, materials, plant and equipment to provide a fully completed connection to the approval of the Engineer.

905.05 Level Adjustment of Existing Manholes, Chambers and the Like

905.05.1 Measurement - Level adjustments of existing manholes, chambers and the like, to the required finished level and as directed and approved by the Engineer, shall be enumerated irrespective of the type, size, and depth

905.05.2 Payment - The rates shall be deemed to include for all necessary excavation and backfilling, partial demolition of existing manholes and disposal of redundant materials, removing, rehabilitating and replacing existing manhole covers and frames, re-building of concrete walls and cover slabs including all necessary concrete, formwork and reinforcement, reinstatement of all existing structures and finishings, applying internal and external protective coatings to new concrete work as specified, all necessary temporary protection and all other works necessary to raise or lower the existing manholes and chambers to the proposed road level.

905.06 Replacement of Manholes Covers and Frames

905.06.1 Measurement - Replacement of manholes covers and frames shall be made by number for each type separately irrespective of the size, as may be encountered on site and directed by the Engineer.

905.06.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities which rate shall include installation, and all labour, materials, equipment and other items or work necessary to complete the works.

905.07 Replacement of Gratings

905.07.1 Measurement - Replacement of gratings shall be measured by kilogram (or metric tones) irrespective of the size and shape.

905.07.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include installation, fixing and all labour, materials, equipment and other items or work necessary to complete the works.

905.08 Sanitary House Connections

905.08.1 Measurement

a. Pipelines for sanitary house connections shall be measured, separately, by linear meter for each pipe diameter and depth in stages of 1 meter with the 1st stage of excavated average depth of trench, as itemized in the Bill of Quantities, extends up to 2m.

b. Sewerage manholes for sanitary house connections shall be enumerated separately for each type, size and depth.

905.08.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities.

a. Rates for pipelines for sanitary house connections shall include, excavation, bedding and surrounding with selected excavated material or selected imported borrow fill material, or encasement of pipes with reinforced concrete and backfilling with suitable excavated material or suitable imported fill materials, pipes and pipe fittings, laying and jointing, interconnections, adaptors, connections to house sewage outlets, testing, all labour, materials and equipment, breaking into and over-pumping of live sewers as necessary, and other items or work necessary to complete the works.

b. Rates for sanitary house connection manholes shall include the items included in the rate of “Manholes” hereinafter.

905.09 Water House Connections

905.09.1 Measurement

a. Pipelines for water house connections shall be measured, separately, by linear meter for each pipe diameter and depth in stages of 1 meter, as itemized in the Bill of Quantities.

b. House connections chambers shall be enumerated separately for each type, size and depth.

905.09.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities

a. Rates for pipelines for water house connections shall include, excavation, bedding and surrounding with selected excavated material or selected imported borrow fill material, or encasement of pipes with reinforced concrete and backfilling with suitable excavated material or suitable imported fill materials, pipes and pipe fittings, laying and jointing, interconnections, adaptors, connections to house inlets, testing, all labour, materials and equipment, and other items or work necessary to complete the works.

b. Rates for house connections chambers shall be deemed to include for reinforced concrete chamber including all excavation, backfilling, concrete work, covers and frames, associated house connection valves, pipe ‘T’ connection, couplings, tapping, ferrule cocks, flushing and disinfections and all labour, materials and equipment and other items and work necessary to complete the works.

905.10 Channels, Ditches, Interceptors, Cascade (concrete Steps) –

905.10.1 Measurements - channels, ditches, interceptors, and cascade (concrete steps) shall be measured by the meter run for each size or type separately.

905.10.2 Payment - Payment shall be made at the respective rates indicated in the Bill of Quantities. Rates for concrete shall include lining, excavation in any type of soil (including rock), bedding material, backfill with selected excavated material or imported borrow fill material as necessary, concrete, reinforcement formwork, joints, trowel finish, protection of

concrete surfaces and all labour, materials, covers and grill (as applicable), equipment and other items or work necessary to complete the works.

905.11 Masonry Block Protection for Waterproofing Membrane

905.11.1 Measurements - Masonry block protection for waterproofing membrane shall be measured by the square meter.

905.11.2 Payment - Payment shall be made at the respective rates indicated in the Bill of Quantities. Rates shall include for all labors, materials, equipment and other items or work necessary to complete the works.

905.12 Replacement of Rubber Gasket for Ductile Iron Pipes

905.12.1 Measurement - Replacement of rubber gasket for ductile iron pipes shall be enumerated irrespective of the pipe diameter.

905.12.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities which rate shall include installation, and all labour, materials, equipment and other items or work necessary to complete the works.

905.13 Valves and Associated Stepped/Flexible Couplings, Tees, Joints and Other Fittings

905.13.1 Measurement – Valves, associated stepped/flexible couplings, tees, joints and other fittings on potable water pipelines shall be enumerated separately stating the type and size or diameter as applicable.

905.13.2 Payment - The rates shall be deemed to include, as appropriate, jointing and connections to pipes, extension spindles and all other associated works complete.

Unless otherwise itemized in the Bill of Quantities, all other pipe fittings, of whatever type, shall be deemed to be included in the Contractor's rates for pipe lines and pipe culverts.

905.14 Box Inlets Covers

905.14.1 Measurement – Box inlets covers shall be made by number for each type separately stating the size, as indicated in the Bill of Quantities.

905.14.2 Payment - Rates for box inlets covers shall include all necessary materials, labour, and other items or work to complete the supply and installation of box culverts.

905.15 Service Ducts in Bridge Sidewalks

905.15.1 Measurement - Measurement shall be made by linear meter for each pipe or duct group separately.

905.15.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities which rates shall include all the pipes or ducts in the group, laying and jointing,

drawwires, temporary plugs, concrete encasement, joints and all labour, materials, equipment and other items or work necessary to complete the works.

905.16 Pipes for Filter Drain

905.16.1 Measurement - Measurement shall be made by linear meter for each diameter of perforated pipe separately.

905.16.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include pipe, jointing, bedding, surrounding, accessories, and all labour, materials, equipment and other items and work necessary to complete the works.

905.17 Natural earth ditch

905.17.1 Measurement – Natural earth ditch shall be measured by the meter run completed and accepted. Dimensions shall be as shown on the drawings.

905.17.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities.

Rates shall include lining, excavation in any type of soil including rock, backfilling with selected material or imported borrow fill as necessary, compacting to the required level, slope surface protection, blinding concrete, all labour, materials, equipments and all necessary items to complete the works.

905.18 Relocation of Existing Sewer Pipes, Stormwater Pipes and Potable water Pipes

905.18.1 Measurement

a. Relocation of existing pipes shall be measured as stated in the Bills of Quantities for each item separately.

905.18.2 Payment

Payment for the relocation of existing pipes shall be at the rates indicated in the Bill of Quantities which rate shall include for all required materials, labors, tools, equipment, disposal of salvaged materials, replacement with backfilling materials and reinstatement of surfaces to same pre-existing conditions.

For pipe installation, refer to Pipework payment section 905.04.1

**** END OF SECTION ****

SECTION – X
SAFETY BARRIERS, MONORAILS & CHAIN LINK FENCE

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SECTION – X

SAFETY BARRIERS, MONORAILS & CHAIN LINK FENCE

1000 – GENERAL

1000.01 Scope - The work shall consist of furnishing and installing safety barriers, monorails and chain link fence. Pedestrian guardrails and Noise barriers as specified in this Specification and as indicated on the Drawings or instructed by the Engineer.

1000.02 Standards and Codes - The work shall be performed in accordance with the standards and codes indicated in the Specification or other equivalent or superior standards applicable to this work and approved by the Engineer.

1000.03 Submittals - The Contractor shall submit to the Engineer for approval the following:

1. Name of manufacturer, applicable standards and full details of the materials and products, together with evidence of satisfactory performance of such materials and products on projects of similar magnitude and nature over the last 5 years.
2. Detailed product data to fully describe and identify each product, accessories, method of installation, characteristics, protective measures against corrosion, strength parameters and any other data required to ascertain compliance of the proposed products with the requirements of the Contract Documents and their suitability for the intended purpose.

No materials or products shall be ordered by the contractor before the Engineer's approval is obtained.

The Contractor shall also prepare and submit to the Engineer shop and construction drawings detailing the location and installation of all elements of the guardrails and barriers. No work shall be commenced by the Contractor before approval of the Engineer is obtained.

All work shall be executed in accordance with approved submittals.

1001 – SAFETY BARRIERS

1. The Contractor shall construct all safety barriers complete with posts, terminal sections, end sections, foundations and all accessories at the locations indicated on the Drawings or as directed by the Engineer.
2. The safety barrier shall be of the corrugated steel beam type conforming to the British Department of Transport Specification for Highway works, type UCB: Untensioned Corrugated Beam.

3. Materials and fabrication of components and fittings shall be as described below and in BS 6579: parts 8 and 9.

Material for the corrugated beams shall conform to BS EN 10025 Grade FE 430 A. Posts and other elements shall conform to the said standard. Tolerances on stock thicknesses of steel plate shall be class C to BS EN 10029. Black bolts, screws and nuts shall comply with BS 4190 and block washers to Section 2 of BS 4320. Stainless steel bolts, screws and nuts shall comply with BS 6105 grade A4-80 and stainless steel washers to BS 4320 of type 304 or 316 to BS 1449. All components except stainless steel items shall be galvanized in accordance with BS 729 with a minimum average coating weight for any individual test area as follows:

- Items 5.5 mm thick or over : 610 g/m²
- Items less than 5.5 mm thick : 460 g/m²
- Bolts, screws, nuts, washers : 305 g/m²

Concrete in foundations and anchor blocks shall comply with the Concrete Section of this specification.

4. All materials and products shall be accompanied by the manufacturer's test certificates and shall be adequately marked and cross referenced.
5. All components shall be protected from damage and handled and stacked in such a way that permanent damage is not caused. Means shall be provided to avoid damage to threaded components & to the galvanized coatings. Transport & storage of galvanized articles shall comply with the recommendations of BS 729: 1971 Appendix C.
6. Installation - All safety barriers shall be erected to present a flowing alignment and unless otherwise agreed with the Engineer in accordance with the following:
 - a) The overall alignment on plan of barrier shall not depart from the prescribed alignment by more than ± 30 mm, nor deviate in any 10m length from the straight or required curvature by more than ± 15 mm. Beams shall be at the heights indicated or directed.
7. Posts shall be installed and concreted as necessary to provide a safe installation as approved by the Engineer. Where posts are to be installed into anchorage systems on to concrete structures, the anchorage system shall be designed by the Contractor to provide adequate resistance and transfer of forces and shears. The anchorage design shall be subject to the Engineer's approval.
8. Beams shall be lapped a minimum of 150 mm in the direction of traffic and shall be securely bolted to the post assembly.
9. Terminal and end sections of the barrier shall be installed in accordance with the applicable standards and as shown on the Drawings.

1002 – BRIDGE PARAPETS

1002.01 General - Bridge parapet shall comprise a concrete parapet (minimum 800mm high) and a single rail aluminium parapet to AASHTO Specifications for combination railing (aluminium parapet with 16.666 kN Highway Design Loading) in accordance with Article 2.7 of Standard Specifications for Highway Bridges, Fifteenth Edition, 1992, all as detailed on drawings. The aluminium Single rail shall be supplied by the Contractor from an internationally recognized manufacturer approved by the Engineer.

1002.02 Materials – Cast posts shall be to Aluminum Association Alloy A444-T4. All extruded sections shall be to Aluminum Alloy 6082-T6 to BS 1474. Plates shall be to Aluminum Alloy 6082-T6 to BS 1470. Holding down bolts shall be of Stainless Steel bolts A4-80 to BS 6105 with aluminum washer and plastic sleeves; bolts shall be sized as per applicable requirements and manufacturer's recommendation. The underside of post baseplate to be given at least two coats of an alkali resistant bituminous pitch or paint complying with BS 3416. End sections, anchorages, post spacings, other ancillary items shall be in accordance with the manufacturer's recommendations and shall conform to approved product data and installation drawings. All materials shall be adequately protected against damage.

1002.03 Fabrication, Welding, and Installation – The fabrication of the Aluminium bridge railing shall conform to the Specifications for Aluminium Structures, Fifth Edition, 1986 and the welding shall conform to Section 10 of the current AWS D1.2 Structural Welding Code- Aluminium and Workmanship requirements for Class II Structures. Concrete parapets shall be installed at the locations designated on the drawings. The overall alignment on plan shall not vary by more than ± 15 mm. The installed levels shall conform to the levels indicated on the approved installation drawings. At expansion joints, suitable expansion assembly shall be provided to allow for the prescribed movements. Installation of the aluminium bridge parapets shall be in accordance with the manufacturer's written instructions and as approved by the Engineer.

1003 – PEDESTRIAN GUARDRAILS

1003.01 General - Pedestrian guardrails shall be an aluminum pedestrian parapet conforming to the British Department of Transport Technical Memorandum BE 5, Type P4 (Design Strength: 1400N/m) for normal applications of 1100 mm nominal height. This type of guardrails shall be installed on pedestrian footbridges and part of the retaining walls as shown on standard details drawings. The aluminum pedestrian parapet shall be supplied by the Contractor from an internationally recognized manufacturer approved by the Engineer.

1003.02 Materials - Aluminum extrusions shall be in 6082-T6 & 6063-T6 alloys to BS 1474. Aluminum weld shall conform to BS 3571: Part1 (MIG) or BS 3019: Part1 (TIG). All holding down bolts, Setscrews, washers and nuts shall be stainless steel to BS 6105 Grade A4-80. All post fixing shall be with suitable baseplate and anchorage assemblies unless otherwise approved by the Engineer. The underside of post baseplate to be given at least two coats of analkali resistant bituminous pitch or paint complying with BS 3416. Parapet Systems shall be supplied and erected under BS5750 approved procedures.

1003.03 Installation - Pedestrian guardrails shall be installed at the locations designated on the Drawings. The overall alignment on plan & levels shall not vary by more than ± 15 mm. Suitable provisions shall be incorporated in the design for expansion joints. Installation shall be in accordance with the manufacturer's written instructions and as approved by the Engineer.

1004 – NOISE BARRIERS

1004.01 General - Noise barriers shall be furnished and installed by the Contractor in accordance with the Specifications and at locations indicated on the Drawings or as directed by the Engineer.

The noise barriers are intended for the attenuation of traffic disturbance and noise in densely inhabited areas adjacent to the road. The barrier shall be capable of high sound absorption and high sound transmission loss.

1004.02 Materials - The noise barriers shall comprise an assembly of support systems and panel sections. Each panel shall be 50 mm deep 16 gauge tray with mineral rock wool infill and covered with perforated 24 gauge face panel. All metal components of the barrier shall be hot dipped galvanized. All support systems and panels shall be designed to withstand wind and other service loads. The choice of materials, manufacture and assembly shall ensure durability, stability and maintenance free installation.

The Contractor shall submit to the Engineer for approval detailed product data, calculations, test results, manufacturer's certificates, installation details and shop and construction drawings of the noise barrier installation.

1004.03 Installation - Installation shall be carried out by the Contractor in accordance with the manufacturer's written instructions and the approved submittals. Painting systems provided by the Contractor shall be compatible with the noise barrier to be installed. Colours and paint system shall be subject to the Engineer's approval.

1004.04 Tests - Sound transmission loss shall be tested in accordance with ASTM E 90 and E 413. Sound absorption shall be tested in accordance with ASTM C 423 and E 795.

1005 – CHAIN LINK FENCE

1005.01 General – chain link fencing with three strands of barbed wire shall be furnished and erected as shown on Drawings.

The natural ground shall be graded and leveled along the fence's center line and for a suitable width that will allow construction of the fence. Excavation of high level areas, filling and compaction operations shall be carried out prior to erection of the fence.

All sizes and dimensions of elements and fittings shown on the Drawings are for guidance purpose only and the Contractor shall submit manufacturer's shop drawings showing final dimensions and details together with specifications and other information for approval.

The fence shall be set true to line, plumbed vertical to the satisfaction of the Engineer.

1005.02 Fences – The fences shall be of the height shown on the Drawings and the line posts shall be an H-section galvanized steel with an extension arm of three strands of barbed wire. The chain link fabric shall be 2 inch each mesh of No.5 gauge zinc-coated complying with ASTM A 392-91.

Line posts shall be provided at 3 meters centers. Hollow circular steel posts shall be provided at corners with an extension arm drilled for three strands of barbed wire and braced by brace posts. The corner posts shall be supplied with two stretcher bars and all necessary hot-dipped galvanized fittings and attachments.

Continuous top hollow circular brace rails shall be supplied with an outside sleeve type coupling spaced at maximum 6 meters centers. Every fifth brace rails coupling shall be of the spring type for expansion.

Tension line wire shall be No.7 gauge and tying wire shall be double strands No.13 gauge. Line wires and barbed wires shall be hot dipped galvanized after weaving.

End fencing panels cornerpanels shall be provided with intermediate hollow circular brace rail complete with circular and square end bands and tensioned with round truss rod complete with bar bands and truss tightner fittings as shown on the Drawings.

All posts shall be set in concrete bases of the Class and dimensions shown on Drawings.

1006 – REMOVABLE STEEL BARRIERS

1006.01 General – Removable steel barrier shall be furnished and erected as shown on Drawings.

1006.02 Removable Steel Barrier– Removable Steel Barrier shall be made of hot dip galvanized steel sheets and pipes assembled and /or welded in accordance with the details of the manufacturers which shall be submitted by the Contractor with proper sample for the approval of the Engineer. The Submittal of the Contractor for the movable barrier shall include data sheets showing the type of materials used and the manufacturing codes and/or standards, test certificates from third party to conform the data sheets, detailed drawings, and others information required by the Engineer. Removable steel barrier shall be of an approved type and similar to HIASA mobile barrier type VGH 55.

1007 – MEASUREMENT AND PAYMENT

1007.01 Safety Barriers

1007.01.1 Measurement - Safety barriers shall be measured by the meter run along the standard length of the barrier excluding terminal section and end section. Terminal section and end section shall each be measured by number.

1007.01.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities which rates shall be deemed to include all materials, labour, equipment, earthwork, concrete, anchorage assemblies and all other items and work necessary to complete the works.

1007.02 Bridge Parapets

1007.02.1 Measurement - Bridge parapets shall be measured as follows:

a. Monorail parapet: shall be measured by meter run along the length of the parapet from end post to end post.

b. Concrete parapet: shall be measured separately in accordance with clause 704.7.1

c. Aluminium parapet: shall be measured by meter run along the length of the parapet from end post to end post.

1007.02.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall be deemed to include all materials, labour, equipment, anchorage assemblies, end sections and all other items and work necessary to complete the works.

1007.03 Pedestrian Guardrails

1007.03.1 Measurement - Pedestrian guardrails shall be measured by meter run along the length of the guardrails from end post to end post.

1007.03.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall be deemed to include all materials, labour, equipment, anchorage assemblies, end sections and all other items and work necessary to complete the works.

1007.04 Noise Barriers

1007.04.1 Measurement - Noise Barriers shall be measured by square meter of the installed barrier.

1007.04.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall be deemed to include all materials, labour, equipment, support systems, anchorage assemblies, coatings and painting and all other items and work necessary to complete the works.

1007.05 Chain Link Fencing

1007.05.1 Measurement - Chain link fencing shall be measured by linear meter, stating the height of the installed fence.

1007.05.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall be deemed to include all materials, labour, equipment, support systems, anchorage assemblies, coatings and painting and all other items and work necessary to complete the works.

1007.06 Removable Steel Barrier

1007.06.1 Measurement – Removable steel barrier shall be measured in linear meter.

1007.06.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall be deemed to include all materials of the removable steel barrier, accessories, labour, equipment, coatings and painting as required, storage handling, transportation of any required number of times, installation and re-installation as needed, and all other items and work necessary to complete the works.

**** END OF SECTION ****

SECTION – XI

TRAFFIC MARKINGS & SIGNS

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1100 – ROADWAY MARKING

1100.01 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 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
 - Reflectorized Cold Paint
 - Preformed Reflectorized Thermoplastic Film
 - Preformed Plastic Tape Extended Service Life
- 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).
 - On roads in areas over 1200 metres above sea level, that are regularly snow-ploughed in winter.
 - For temporary road markings.
 - For yellow painted kerbs 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.

1100.02 MARKING COLORS

- A. This section covers the daytime and night-time color of retroreflective pavement marking materials used for traffic control lane markings and symbols on road surfaces. It is intended to apply throughout the service life of the material.
- B. Pavement marking colors for all types shall conform with ASTM D6628.

- C.** Daytime color shall be measured in accordance with Test Method E1349, using 45/0 (0/45) geometry, CIE illuminant D65 and the 1931 CIE 2° standard observer. Night-time chromaticity shall be in accordance with Test Method E811 using the geometric tolerance and sample positioning (including angle setting techniques) as described in Test Method D4061.
- D.** Color coordinates of samples shall lie within the lines drawn between the corner points which specify the chromaticity limits.

Corner Point	Coordinates	Daytime		Night-time	
		White	Yellow	White	Yellow
1	x	0.355	0.560	0.480	0.575
	y	0.355	0.440	0.410	0.425
2	x	0.305	0.490	0.430	0.508
	y	0.305	0.510	0.380	0.415
3	x	0.285	0.420	0.405	0.473
	y	0.325	0.440	0.405	0.453
4	x	0.335	0.460	0.455	0.510
	y	0.375	0.400	0.435	0.490

- E.** Alternatively, all pavement markings, without drop-on beads and/or media, shall visually match the colors that correspond to the Federal Standard Number 595b for the following colors:
- White: Color No. 17886
 - Yellow: Color No. 13538
- F.** In-service daytime luminance factor limits (tristimulus value Y expressed as a percent) apply when measured with 45°/0° geometry using a standard illuminant D65 and a CIE 2° standard observer (without drop-on beads) in accordance to ASTM D 6628 or ASTM D4960 (for thermoplastics).

Color	Daylight Reflectance at 45°/0°
White	75%
Yellow	45%

- G.** For white markings, the yellowness index shall be 10 maximum when tested in accordance with ASTM D562 or AASHTO T250 (for thermoplastics).

1100.03 MATERIALS

1100.03.1 Thermoplastic ReflectORIZED Paint (TRP)

A. General

- A.1** 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.
- A.2** Thermoplastic striping material shall comply with AASHTO M 249 or any other equivalent standard except when specified otherwise.

B. Composition

- B.1** The thermoplastic markings composition shall conform to the following requirements. The components shall be thoroughly mixed to ensure that the pigment, glass beads and filler are uniformly dispersed in the resin.

Component	White	Yellow	Test Method
Binder (hydrocarbon or alkyd)	Min. 18%	Min. 18%	
Glass Beads	30% – 40%	30% – 40%	ASTM D467
Titanium Dioxide (TiO ₂)	Min. 10%	Manufacturer Specific	AASHTO T250
Calcium carbonate and Inert Filler	Max. 42%	Manufacturer Specific	
Yellow Pigments	-	Min. 4%	

- B.2** The specific gravity of the white or yellow thermoplastic compound shall not exceed 2.15.

C. Reflective Glass Beads

- C.1** Glass beads shall be applied on the surface (drop-on) or incorporated into (inter-mix) the traffic marking material.

- C.2** Beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and weather. The glass beads shall be transparent, clean, colorless glass, smooth and spherically shaped, and free from milkiness, pits, or excessive air bubbles. The material shall be free from all skin, dirt, and foreign objects.
- C.3** Glass beads shall conform to AASHTO M247.
- C.4** The glass beads of the surface applied beads shall meet the following sieve requirements.

Sieve Gradation		Mass % Passing	
Sieve size (mm)	Sieve No.	Type I: Standard	Type II: Uniform
0.850	20	100	-
0.600	30	75 - 95	100
0.425	40	-	90 - 100
0.300	50	15 - 35	5 - 75
0.180	80	-	0 - 5
0.150	100	0 - 5	-

- C.5** The intermix glass beads when tested in accordance with ASTM D1214 shall have the following graduation.

Sieve size (mm)	Sieve No.	Percentage Passing by Weight
1.700	12	100
0.180	80	0 - 5

- C.6** 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.
- C.7** 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.
- C.8** 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°C, and the spheres automatically applied to the surface of the TRP line shall have a minimum index of refraction of 1.5.

- C.9** The silica content (SiO₂) of the spheres shall be 60% plus or minus 5% when tested in accordance with Federal Test Method 141a.
- C.10** 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 of immersion.
- C.11** Moisture Resistance - Flow Characteristics: The beads shall not absorb moisture in storage. They shall remain free of clusters and lumps and shall flow freely from dispensing equipment.
- C.12** Packaging: Glass beads shall be furnished in lots and packaged in moisture-proofed bags. Containers are to be guaranteed to furnish dry and undamaged beads. Each package shall contain the following information: name, and address of manufacturer, shipping point, trademark or name, the wording "glass beads", the specification number, number of the lot or batch number and the month and year of manufacture.
- C.13** Unless otherwise specified on the Drawings, thermoplastic materials based on alkyd resins shall be used in urban settings with a minimum Shore A hardness at 45°C of 60, a Brookfield thermoseal viscosity of between 45 and 100 and a minimum flash point of 230 °C. The drying time at an ambient temperature of 32 °C shall be 5 minutes.
- D. Physical Requirements**
- D.1** In the plastic state, the thermoplastic material shall not exude fumes which are toxic, injurious, or require specialized breathing apparatus when heated as specified for application.
- D.2** Thermoplastic material shall melt uniformly with no evidence of skins or unmelted particles.
- D.3** The material shall provide a stripe that has a uniform color and thickness throughout its cross section and has the density and character to provide a sharp edge of the line.
- D.4** The thermoplastic material shall have a softening point of 102.5 ± 9.5°C after heating for 240 ± 5 min at 218 ± 2 °C in accordance with ASTM D36.

D.5 The thermoplastic material shall pass without showing cracks when applied on concrete blocks and heated for 240 ± 5 min at 218 ± 2 °C then cooled to -9.4 ± 1.7 °C in accordance to AASHTO T250.

D.6 The thermoplastic material shall have an impact resistance not less than 1.13J (10 in-lb) after heating for 240 ± 5 min at 218 ± 2 °C when tested in accordance with AASHTO T250.

D.7 The flowability of the thermoplastic material as tested based on AASHTO T250 after heating for 240 ± 5 min at 218 ± 2 °C shall satisfy the following requirements:

- White: Max. 18% residue
- Yellow: Max. 21% residue

Flowability tested in accordance to AASHTO T250 upon extended heating for 480 ± 30 min at 218 ± 2 °C shall not exceed a maximum percent residue of 25% regardless of the pigment color.

D.8 The thermoplastic material shall have a flash point no less than 260°C when tested in accordance with Test Method ASTM D92.

D.9 The minimum dry retroreflectivity of the markings when tested 180 days or less after installation shall be as follows when tested according to Test Method E1710:

	White	Yellow	Test Method
Retro-reflectivity (R_L) mcd/m ² /lux	Min. 300	Min. 200	ASTM E1710

D.10 The minimum dry retroreflectivity of the markings of all classes when tested from 181 days after installation through the end of service life of the markings shall be as follows when tested according to Test Method E1710:

- White: 150 mcd/m²/lux
- Yellow: 125 mcd/m²/lux

D.11 The material shall maintain a granular free-flow condition in dry storage for a minimum of one year, providing the temperature does not exceed 40°C.

1100.03.2 Cold Paint Pavement Marking

A. General

- A.1** Pavement marking paint shall be water-based (latex) or solvent-based (alkyd) white or yellow ready mixed one-component type with spraying consistency suitable for use as a retroreflective pavement marking.
- A.2** 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.
- A.3** Reflectorized white and yellow solvent-based traffic paint shall conform to AASHTO M-248, Type F. The surface application of glass spheres shall conform to AASHTO M 247, Type I.
- A.4** Paint markings shall be free of lead and chromium with a limited quantity of volatile organic compounds (VOC).

B. Composition

B.1 Water-based Paint Pavement Marking

The paint markings composition shall be low VOC solvents that conform to the following requirements.

Paint Properties	Test Method	Water-based Paint			
		White		Yellow	
		Min.	Max.	Min.	Max.
Total Non-volatiles, (solids), % by weight	ASTM D2369	75	-	75	-
Pigment Content, % by weight	ASTM D3723	57	62	57	62
Non-volatile Vehicle (NVV), % by weight	ASTM D2369 ASTM D3723	40	-	40	-
Titanium Dioxide, rutile type II, g/L	ASTM D476	120	-	-	-
Volatile Organic Content, (VOC), g/L	ASTM D3960	-	150	-	150

B.2 Solvent-based Paint Pavement Marking (Type F)

The paint markings composition shall be low VOC solvents that conform to the following requirements.

Paint Properties	Test Method	Solvent-based Paint			
		White		Yellow	
		Min.	Max.	Min.	Max.
Total Non-volatiles, (solids), % by weight	ASTM D2369	65	-	65	-
Pigment Content, % by weight	ASTM D2698	-	53	-	53
Lead Content, %	ASTM D3335	-	0.06	-	0.06
Titanium Dioxide, rutile type II, g/L	ASTM D4563	120	-	-	20
Volatile Organic Content, (VOC), g/L	ASTM D3960	-	150	-	150

C. Reflective Glass Beads

C.1 The same requirements as drop-on glass beads for Thermoplastic ReflectORIZED Paints apply (Section 1100.03.1-C).

D. Physical Requirements

D.1 Water-based paint pavement markings shall conform with the following requirements.

Paint Properties	Test Method	Water-based Paint			
		White		Yellow	
		Min.	Max.	Min.	Max.
Density (kg/L)	ASTM D1475	Within ± 0.024 kg/L of qualification sample			
Viscosity at 25°C, KU	ASTM D562	80	95	80	95
Fineness of Grind, HEGMAN	ASTM D1210	3	-	3	-
Dry Opacity/Contrast Ratio at 0.38 mm WFT	ASTM D2805 (2°, D65)	0.96	-	-	-
Bleed Ratio	ASTM D969	Reflectance measurement of the alkyd resin paint over asphalt paper shall be at least 95 % of the reflectance measurement of the material over a taped (non-bleeding) surface.			
Flexibility	ASTM D522 Method B	Pass	-	-	-
Scrub Resistance	ASTM D2486	800	-	-	-
Freeze-thaw and Heat stability	ASTM D2243 & D562	± 10 KU from the initial viscosity	-	-	-
Flash Point,	ASTM D93	38°C			
Laboratory Dry Time (Minutes)/ Dry time to no pick up	ASTM D711		10		
Dry Through Time, minutes	ASTM D 1640		20		
No-track time (dry to no-pick-up time for pavement marking), minutes	Measure time required for the line to withstand the running of a Standard sedan at a speed of 65 km/hr, simulating a passing procedure without tracking of the reflectorized line when viewed from a distance of 15 m.	3 minutes when applied to a for 0.38 ± 0.03 mm film thickness at pavement temperatures 54.4 -65.6 °C.			

D.2 Solvent-based paint pavement markings shall conform with the following requirements.

Paint Properties	Test Method	Solvent-based Paint			
		White		Yellow	
		Min.	Max.	Min.	Max.
Density (kg/L)	ASTM D1475	1.5		1.5	
Viscosity at 25°C, KU	ASTM D562	75	85	75	85
Settling Properties during Storage, cm	ASTM D1309	-	20	-	30
Skinning	ASTM D154	The paint shall not skin within 48 hours in a $\frac{3}{4}$ filled, tightly closed container			
Bleed Ratio	ASTM D969	Reflectance measurement of the alkyd resin paint over asphalt paper shall be at least 90 % of the reflectance measurement of the material over a taped (non-bleeding) surface.			
Flexibility	ASTM D522 Method B	Pass			
Package Stability	ASTM D1849	6	-	6	-
No-track time (dry to no-pick-up time for pavement marking), minutes	Measure time required for the line to withstand the running of a Standard sedan at a speed of 65 km/hr, simulating a passing procedure without tracking of the reflectorized line when viewed from a distance of 15 m.	1.5 minutes when applied to a for 0.38 \pm 0.03 mm film thickness at pavement temperatures 54.4 - 65.6 °C.			

D.3 After storage for periods up to 6 months from date of packaging, the pigment shall be readily dispersed and viscosity of the paint shall not have changed more than 5 KU from that of the freshly delivered paint.

1100.03.3 Preformed Thermoplastic Reflectorized Film

A. General

- A.1** Thermoplastic shall be used as a preformed (pre-shaped) material for arrows, stop bars, pavement signs and text markings.
- A.2** Preformed thermoplastic reflectorized film shall conform to the requirements of EN 1790.
- A.3** 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.
- A.4** All material used in the formulation of the preformed thermoplastic pavement marking shall meet the requirements to the standard thermoplastic in addition to the requirements specified herein.

B. Composition

- B.1** The preformed thermoplastic film shall consist of the following:

Component	Minimum % by weight
Resins and Plasticizers	20
Pigments	30
Reflective Glass Beads	20

C. Glass Beads

- C.1** The same requirements as drop-on glass beads for Thermoplastic Reflectorized Paints apply (Section 1100.03.1-C).

- C.2** Glass beads shall be uniformly distributed throughout the entire cross-sectional area. Immediate retroreflectivity can be provided by a pre-applied layer of beads or by scattering surface beads on a molten material during application. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.

D. Physical Requirements

- D.1** All material used in the formulation of the preformed thermoplastic pavement marking shall meet the requirements to the standard thermoplastic in addition to the requirements specified herein.
- D.2** 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 shall 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.3** The marking shall be capable of conforming to pavement contours, breaks, and faults under the action of traffic at all pavement temperatures.
- D.4** The film shall have resealing characteristics and shall be capable of fusing with itself or with previously applied marking material.
- D.5** The preformed thermoplastic material shall be resistant to deterioration due to the exposure to sunlight, water, oil, gasoline, salt or adverse weather conditions.
- D.6** The surface of the marking shall provide a minimum skid resistance value of 45 BPN when tested according to ASTM E 303.
- D.7** The plastic film shall be sufficiently flexible so that at a temperature of 26 to 28°C, an unmounted piece of material (without adhesive and paper backing), 75 mm by 150 mm in size, may be bent over a 25 mm mandrel until the end faces are parallel and 25 mm apart without showing any fracture lines in the uppermost surface.
- D.8** The preformed thermoplastic markings shall not be brittle and must be sufficiently cohesive and flexible at temperatures exceeding 10 °C for one person to carry without the danger of fracturing the material prior to application.

1100.03.4 Preformed Plastic Tapes Extended Service Life

A. General

- A.1** A permanent preformed tape is any material that bonds with the pavement surface and has a service life of at least 1 year.
- A.2** Preformed tapes are frequently used for transverse markings but are often used for longitudinal lines in high-traffic areas.
- A.3** Preformed tapes are cold-applied, preformed pavement marking materials that are supplied in continuous rolls of various lengths and widths.
- A.4** Preformed pavement markings shall be a retroreflective film on a suitable backing.
- A.5** White or yellow marking tape shall consist of glass spheres of high optical quality embedded into a binder on a suitable backing that is precoated with a pressure sensitive adhesive.

B. Composition

- B.1** The preformed plastic tape composition without adhesive shall conform to the following requirements.

Component	Minimum % by weight
Resins and Plasticizers	20
Pigments	30
Reflective Glass Beads	20

- B.2** The remaining materials shall comprise the remaining 30% in various proportions, subject to approval of the Engineer.

C. Physical Requirements

- C.1** The physical requirements of preformed tape markings shall conform with ASTM D4505.
- C.2** The marking tape shall adhere to roadway surfaces when applied according to the manufacturer's recommended procedures on pavement surfaces having temperatures down to 10 °C.

C.3 The marking shall be capable of conforming to pavement contours, breaks, and faults under the action of traffic at all pavement temperatures. The film shall have resealing characteristics and shall be capable of fusing with itself or with previously applied marking material.

C.4 The tape shall provide a neat, durable marking that will not flow or distort due to temperature and other weather factors. The markings shall provide a cushioned resilient substrate that reduces bead crushing and loss. The markings shall be weather resistant and show no appreciable fading, lifting, tearing, rollback, or other signs of poor adhesion when subject to normal traffic conditions.

C.5 The surface of the markings shall provide the following minimum skid resistance values when tested according to ASTM E 303.

Type B	45 BPN
Type C	55 BPN

C.6 The tape shall have the following minimum tensile strength of cross section when tested according to ASTM D 638-76 using a jaw speed of 250 to 300 mm/min.

Marking Type	Tensile Strength (kPa)	Elongation
Type B	N/A	N/A
Type C	Min. 1033 kPa	Min. 50%

C.7 No line shall be displaced, be torn or missing.

C.8 The marking tape shall be retroreflective, reflecting white or yellow, respectively, and shall be readily visible when viewed with automobile headlights at night and shall have minimum initial reflective values as shown in the table below.

	White	Yellow	Test Method
Retro-reflectivity (RL) mcd/m ² /lux	300	200	ASTM E1710
	250	175	

C.9 The marking tape as supplied shall have a minimum shelf life of one year from date of purchase when stored at temperatures under 38 °C.

1100.04 APPLICATION AND INSTALLATION

A. Ambient and Pavement Application Temperature

- A.1** Pavement marking operations shall not take place when temperatures are beyond the following limits.

Material	Surface Temperature	Material Application Temperature
Thermoplastic	Min. 13 °C Max. 82 °C	205 – 245 °C
Paint	Min. 10 °C Max. 82 °C	38 °C (heated to reduce drying time)
Preformed Thermoplastic	Min. 10 °C Max. 82 °C	Manufacturer Specific
Preformed Plastic Tapes	Varies with manufacturer and adhesive 15 °C	65 °C (Inlay method) 21 °C (Overlay method)

- A.2** Wind chills should always be considered when determining ambient air temperature.
- A.3** For elevation changes greater than 300 m, temperature at the highest point shall govern.
- A.4** Wind speed also affects the accuracy of the drop-on bead application. Markings using drop-on beads should not be placed on days with excessively high winds.

B. Surface Preparation

- B.1** Remove all dirt, dust, grease, oil, or other detrimental material from the road surface by sweeping and the use of high-pressure air spray.
- B.2** Primer-sealers shall be applied to existing hot mix asphaltic concrete surfaces prior to application of the thermoplastic material and shall be applied as recommended by the thermoplastic material manufacturer.
- B.3** Restriping above existing pavement marking is permitted if the existing marking was 90% worn away or eradicated
- B.4** 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.

C. Surface Moisture

C.1 The presence of moisture on the pavement surface prior to marking placement will affect the bond formed between the pavement marking and the pavement surface.

C.2 Surface moisture is inspected as follows:

- 1) A 30x30 cm square plastic wrap is placed in the pavement surface and the edges are affixed using duct tape.
- 2) The plastic wrap is left on the surface for 15 minutes.
- 3) The formation of bubble is then inspected. If moisture bubbles on the plastic are larger than a pencil eraser, then the pavement contains too much excess water. In such cases all marking operations are postponed until the surface is dry.

D. Pavement Marking Thickness

D.1 The minimum recommended pavement marking thicknesses are as follows.

Type		Baseline Thickness
Standard Thermoplastic	Edge lines, gore lines, diagonals and arrow symbols	New marking – min. 2.3 mm Restriped marking (on thermoplastic) – min. 1.5 mm
	In-lane and shoulder-transverse pavement markings	Min. 6 mm (may be applied in 2 passes)
	Center lines, skip lines, transverse bands, mini-skip lines, characters, bike lane symbols and crosswalk lines	Min. 3 mm
Preformed Thermoplastic	--	3.2 mm
Paint	Standard application	0.38 mm
	Durable high build applications (2 coats)	0.64 mm
Preformed Plastic Tapes Extended Service Life	Long Lines	1.5 mm
	Transverse pavement markings and symbols	2.3 mm

- D.2** Random samples shall be taken at maximum intervals of 600 m to measure their thickness. If three or more successive readings meet the thickness criteria, the Engineer may designate an alternative interval.
- D.3** The marking thickness is measured using a small metal strip with a known thickness. The metal strip shall be placed immediately ahead of the striping apparatus. The plate shall be removed after the pavement marking material and glass beads have been applied at the normal rate and the sample has cooled sufficiently so that no deformation to the stripe occurs when removing the plate from the roadway.
- D.4** A thickness tolerance not exceeding plus 10% will be allowed for thickness or yield in paint and plastic material application.

E. Marking Application Equipment

- E.1** Prior permanent application, marking machine shall demonstrate satisfactory operation on a suitable site which is not part of the permanent works.
- E.2** Pavement marking machines shall be capable of producing at least two parallel lines simultaneously and producing lines with uniform widths within the tolerances specified without the paint running or splashing. Machine shall be further capable of painting lines of different widths by adjusting the spray jets on the machine or by means of additional equipment attached to the machine and applying the pavement marking material and glass beads to a uniform film thickness at the specified rates of application.
- E.3** 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. The hand application equipment shall be sufficiently manoeuvrable to install centrelines, lane and edge lines, gore striping, turn lines, crosswalks, stop lines, kerb lines, arrows and legends.
- E.4** 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.
- E.5** 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.

E.6 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 a maximum of 100 kg of molten material unless otherwise agreed with the Engineer.

E.7 Glass beads dispensing equipment which apply glass beads by means of gravity only shall not be used. Glass beads shall be sprayed onto the paint layer by means of a pressure sprayer except that for small areas, such as application of traffic symbols, hand or gravity application of glass beads may be allowed. 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.

E.8 Thermoplastic Application Equipment shall be capable of:

- 1) Maintaining the thermoplastic material in a plastic state at all stages from mixing to application;
- 2) Incorporating functional and calibrated temperature sensing devices during all melting applications.
- 3) Providing automatic application of glass beads immediately behind the installed line through an automatic glass beads dispenser attached to the striping equipment.
- 4) Allow Dispensing and distributing drop-on glass beads evenly to the surface of the completed marking
- 5) Operating at a speed ranging between 3.2 to 12 kph.

E.9 The main components of thermoplastic marking equipment shall include the following:

- 1) Melting Kettle: Kettle is oil/air jacketed for uniform heating and melting of the thermoplastic material. It is typically equipped with an automatic thermostat control device to provide temperature control and continuous mixing and agitation of the thermoplastic material. The temperature is typically maintained above 205°C. Pre-melting thermoplastic material shall be avoided in handler type equipment.
- 2) Mixing and Agitating Equipment: Mixing equipment shall be capable of thoroughly mixing the material at a rate that ensure even disbursement of the material and uniform temperature distribution.

- 3) Glass Bead Application Equipment: A drop on glass bead system is essential to be used in both mobile and portable thermoplastic applications.
- E.10** Preformed Thermoplastic markings are applied using a propane blow torch or any other manufacture recommended equipment capable of heating the thermoplastic in place.
- E.11** Paint type pavement markings shall be applied using motorized airless striping machines. Paint may be brushed or rolled into the pavement surface for non-linear or kerb applications.
- E.12** Preformed Plastic Tapes are mechanically applied using mobile pavement marking machines specifically designed for use in applying pressure sensitive pavement marking tape of varying widths shall be used. Hand rolling using a tamper cart (roller loaded with at least 90 kg) is permissible for symbols and legends asper the manufacturer's recommendations.

F. Thermoplastic Reflectorized Paint (TRP) Application

F.1 Thermoplastic material shall be applied by spraying, screed extrusion, or ribbon extrusion, as shown in the Contract plans or as directed by the Engineer. The advantage and disadvantages are as follows.

Application Method	Description	Advantages	Disadvantages
Gravity Extrusion	<p>Consists of the thermoplastic material passing through a heated four-sided die, of which three sides are in direct contact with the pavement surface</p> <p>Shall be applied using truck-mounted units.</p>	<ul style="list-style-type: none">- Lines are crisp and well defined on smooth surfaces- Easy to control line thickness and width.- Ensures maximum burn in bonding to asphalt surfaces- Shielded from air and wind, thus preventing loss in temperature at the point of application	<ul style="list-style-type: none">- Slow application rate- Hard to maintain good line definition on rough surface
Ribbon Application	<p>Consists of the thermoplastic material passing through a heated four-sided die suspended above the road surface, applying a forced extrusion, well-defined thermoplastic line.</p> <p>Shall be applied using truck-mounted units or motorized ride-on equipment.</p>	<ul style="list-style-type: none">- Lines are well defined on irregular surfaces- Moderate application rate- Better control of line thickness and width compared to spray application	<ul style="list-style-type: none">- Difficult to obtain uniform thickness- Difficult to achieve maximum burn in bonding to asphalt surfaces in marginal ambient temperature as well as in cool windy conditions.
Hot Sprayed	<p>Consists of the thermoplastic material passing through a spray gun under pressure.</p> <p>Shall be applied using truck-mounted units or motorized ride-on equipment.</p>	<ul style="list-style-type: none">- Maximum adhesion to pavement surface- Fastest application rate- Provides good thermal and mechanical bond	<ul style="list-style-type: none">- Lines can be less crisp and well defined due to the potential of over spraying- Difficult to maintain uniform thickness across the width.

- F.2** To ensure optimum adhesion, the thermoplastic paint shall be applied in a molten state within a temperature range of 204 and 227°C or as recommended by the manufacturer.
- F.3** Specified temperature requirements shall be maintained at all times during application.
- F.4** Total heating time for any batch of material shall not exceed six hours.
- F.5** The contractor shall minimize the thermoplastic material remaining in the kettle at the end of the work day and shall blend a minimum of 80 percent fresh material at the start of each day.
- F.6** Drop-on glass beads must be mechanically deposited after applying the thermoplastic line at a rate ranging between 0.35 and 0.5 kg/m² or as recommended by the manufacturer, into the thermoplastic material immediately after the thermoplastic marking is applied.
- F.7** Glass beads shall be uniformly applied on the entire pavement markings surface with 50 to 60% embedment.
- F.8** The application rate of the thermoplastic material varies with thickness as follows.

Thickness, mm	Maximum Solid Material Yield (m ² /23 kg bag)
1.5	4.7
2.3	3.7
3.0	2.9

- F.9** 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.
- F.10** After application the road shall be opened to traffic in 2 to 10 minutes if the ambient temperature is 10°C or 32°C respectively.

G. Cold Paint Application

- G.1** Typically, the optimal speed of a striping truck applying 0.38 mm markings is 15–30 kph.
- G.2** For reflectorized markings, glass beads shall be applied immediately after the pavement marking material has been applied at a rate of 0.85 kg/litre of paint for a thickness of 0.38 mm. The sphere dispenser shall embed at least 65% of the sphere diameter into the surface.

- G.3** When two applications of paint are required to complete all paint markings, the second application shall be squarely on top of the first pass. The time period between paint applications will vary depending on the type of pavement and paint.

Type	Time period
Water-Based Paint	4 hrs to 30 days
Solvent-Based Paint	40 min to 30 days

- G4.** 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.

H. Preformed Thermoplastic Application

- H.1** Specific application requirements may vary with manufacturer, and therefore manufacturer specifications shall always be followed.

I. Preformed Plastic Tapes Extended Service Life

- I.1** The manufacturer's application procedures for preformed tape must be strictly followed.
- I.2** Preformed plastic tapes may be inlaid or overlaid.
- I.3** The inlay method is preferred on newly constructed or resurfaced asphalt pavement due to its superior performance and excellent bond. Application usually follows the pavement breakdown roller when the pavement temperature is still warm but has cooled to approximately 65°C. The tape is then rolled into the pavement surface with a steel drum roller during the final rolling of the pavement. The roller fuses the plastic into the hot asphalt surface creating an excellent bond and sealing out moisture.
- I.4** The overlay method is used over existing pavements. The tape is applied directly on and bonded to the surface with a pressure sensitive adhesive. Tape shall be initially tamped into place with a light hand roller or vehicle tire with a weight as recommended by the manufacturer.

J. Kerb Paint Application

- J.1** 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.

K. Protection of Markings

- K.1** 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.
- K.2** 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.
- K.3** 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 so that it will be unnecessary for public traffic to cross the newly placed material behind the equipment in order to safely pass the equipment.
- K.4** Protective and traffic warning devices shall be approved by the Engineer before any placement.

L. Tolerances and Finish

- L.1** 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.
- L.2** 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.

- L.3** 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.

1100.05 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. The characteristics shall also be assessed at any other time during the period from the application of test markings to the end of the defects liability period, if instructed by the Engineer:
- 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.

1100.06 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.

1100.07 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 units consisting of a 36 m line and a 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.

1100.08 MEASUREMENT

- A.** 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.
- B.** Painted Kerbstones shall be measured by the linear metre of kerb painted, cured and accepted.

1100.09 PAYMENT

PAY ITEMS

UNIT OF MEASUREMENT

<i>(each type of paint/colour)</i>	Square metre (m ²)
Painted Pavement Markings <i>(each type of paint/ colour)</i>	Square metre (m ²)
Preformed Film Markings <i>(each colour)</i>	Square metre (m ²)
Painted Kerbstones <i>(each colour)</i>	Linear metre (m)

1100.10- Raised Pavement Markers

1100.10.1 Description

This work shall consist of furnishing and installing raised pavement markers of the type specified in the Plans, in accordance with these Specifications, and at the locations indicated in the Plans or where designated by the Engineer. The color of raised pavement markers shall conform to the color of the marking for which they supplement, substitute for, or serve as a positioning guide for.

1100.10.2 Materials

Raised pavement markers (RPM) shall consist of:

- a. Mountable Aluminum Casting with 2 reflective surfaces (Type I)
- b. Circular ceramic (Type II)
- a. Other types as indicated on the Drawings

The markers shall be of a permanent type intended to provide reflectivity for at least three years under normal traffic conditions. The marker housing shall contain reflective faces as shown in the Plans to reflect incident light from either a single or opposite directions.

1100.10.3 Physical Properties

The markers shall be 10 cm in width, but not more than 15 cm in length, and not more than 2 cm in height.

The outer surface of the marker housing shall be smooth.

The base of the markers shall be substantially free from gloss or substances that may reduce its bond to adhesive.

1100.10.4 Optical Requirements

- a. Definitions: Horizontal entrance angle shall mean the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker.

Observation angle shall mean the angle at the reflector between the observer's line of sight and direction of the light incident on the reflector.

Specific Intensity (S.I.) shall mean candlepower of the returned light at the chosen observation and entrance angles for each foot-candle of illumination at the reflector on a plane perpendicular to the incident light.

- b. Optical Requirements: The specific intensity of each reflecting surface at 0.2 degrees observation angle shall be not less than the following when the incident light is parallel to the base of the marker.

Hor. Ent. Angle	S.I.
0	3.0
20	1.2

Yellow reflectors shall be not less than 60 percent and red reflectors not less than 25 percent of the above values.

- c. Optical Testing Procedure: a random lot of markers will be tested. The markers to be tested shall be located with the center of the reflecting face at a distance of 1.5 m from a uniformly bright light source having an effective diameter of 5 mm.

The photocell width shall be 1.25 mm. It shall be shielded to eliminate stray light. The distance from light source center to the photocell center shall be 5 mm. If a test distance of other than 1.5 m is used, the source and receiver dimensions and the distance between source and receiver shall be modified in the same proportion as the test distance.

Failure of more than 4 percent of the samples shall be cause for rejection of the batch.

1100.10.5 Strength Requirements

- a. Markers shall support a load of 1000 Kg as applied in the following manner:
- b. A marker shall be centered over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 2.5 cm high with an internal diameter of 7.5 cm and wall thickness of 6mm. The load shall be slowly applied to the top of the marker through a 2.5 cm diameter by 2.5 cm high metal plug centered on the top of the marker.
- c. Failure shall constitute either a breakage or significant deformation of the marker at any load of less than 1000 Kg.

1100.10.6 Adhesive for Lane Markers

a. Description

The adhesive shall be furnished as two components, each packaged separately. The components shall have the following composition:

<u>Package A</u>	<u>Parts by Mass</u>
Epoxy Resin ¹	87.00
Aliphatic Glycidyl Ether ²	13.00
Titanium Dioxide ASTM D 476 Type I or Type II	3.00
Talc ³	30.00
Fibrillated Polyethylene Fiber ⁴	4.00 *
Silicone Anti-Foam. Type DB100. 100% Solids	0.005

<u>Package B</u>	<u>Parts by Mass</u>
N-Aminoethyl Piperazine ⁵	23.16
Nonyphenol ⁶	52.00
Furnace Black ⁷	0.10
Talc ³	70.00
Fibrillated Polyethylene Fiber ⁴	0.70 *
Silicone Anti-Foam. Type DB100. 100% Solids	0.005

* A range of 3.0 to 5.0 parts is permitted in Package A and 0.5 to 1.0 parts in package B to achieve the required viscosity and shear ratios

¹ Di-glycidyl ether or bisphenol A: Brookfield Viscosity, 10 – 16 Pa/s (100 – 160 poise) at 25°C: epoxideequivalent 180 – 200: colour Gardner 1933, 3 max

² Aliphatic mono functional reactive glycidal ether, derived from an alipathatic alcohol: Brookfield viscosity at 25°C, 1-15 mPa/s (1-15 Centipoise); epoxide equivalent 220 – 250; specific gravity 0.88 – 0.95.

³ Specific Gravity 2.68 to 2.86

Oil Absorption, ASTM D 281 33 to 39

pH 8.1 to 8.6

Hegman Rating 4 to 6

Particle Shape Platey

Maximum Particle Size, Microns 55

Percent passing 45-µm (U.S. No. 325) Screen, min 99

Dry Brightness, minimum 86

⁴ High density, fluff dried, pure fibrillated polyethylene; melting point 120°C -130°C; specific gravity 0.915 - 0.965; molecular mass, 30000 – 150000; fibre size, average length, 0.90 mm diameter, 10 microns; fibre strength, 31.4 – 39.2 Mpa; elongation at rupture, 45 – 57 percent; moisture content, less than 2 percent.

⁵ Colour (APHA), 100 maximum; amine value based on titration which reacts with the 3 nitrogens in the molecule (1250 – 1350); appearance, clear and substantially free of suspended matter.

⁶ Colour (APHA), 100 maximum; hydroxyl number , 245 – 255; water (Karl Fischer) 0.05 percent maximum

⁷ Surface area, 115 – 130, m²/g; particle diameter, 18 – 30 millimicrons; pH 7.0 –8.5; fixed carbon (moisture free) 96 – 98 percent; volatile matter, 1 –4 percent; oil absorption, stiff paste endpoint, 0.80 – 0.90 mL/g.

At the time of use, the contents of packages A and B shall be thoroughly dispersed by mixing. One volume or weight of Package A shall be mixed with one volume or weight of Package B until a uniform grey color is achieved. The maximum acceptable variation in mix ratio shall be five from the 50/50 ratio (45A to 55B or 55A to 45B). The mix ratio shall be determined by analysis for Nitrogen percentage in the mixed and cured adhesive.

- b. A blend of 1 part of component A and 1 part of component B shall exhibit the following properties:

Gel time (150 g. Batch) 5 - 10 minutes

Tensile strength 1.6 mm

film between steel blocks

cured 24 hours at 20°C

Tested at 20°C	1,000 psi (Min.)
Shore D Hardness	70-80 (Cured 24 hours at 20°C)
Tested at 20°C	
Tested at 50°C	(Min.) 30
Deformation Temp.	(Min.) 50°C
Viscosity of Mixed Adhesive	1,000 - 2,000 poise

- c. Adhesive for lane markers may be accepted by the Engineer based on the Manufacturer's Certificate of Compliance. The manufacturer shall certify that each batch of adhesive conforms to the above specifications.

The lot or batch number shall appear on the certificates, on all samples, and on all lots of adhesives delivered.

1100.10.7 Construction Requirements

All sand, dirt, and loose extraneous material shall be swept or blown away from the marker location and the cleaned surface prepared by one of the following procedures:

All surface dirt within areas to receive markers shall be removed. Large areas of tar, grease, or foreign materials may require sandblasting, steam cleaning, or power brooming to accomplish complete removal. Application of markers shall not proceed until final authorization is received from the Engineer.

The pavement shall be surface dry, and in cool weather shall be heated by intense radiant heat (not direct flame) for a sufficient length of time to warm the pavement areas of marker application to a minimum of 20°C.

Markers may be warmed prior to setting by heating to a maximum temperature of 45°C for a maximum of 10 minutes.

The adhesive shall be maintained at a temperature of 15°C to 30°C before use and during application.

Component A shall be added to component B just before use and mixed to a smooth uniform blend. The unused mixed adhesive shall be discarded when polymerization has caused stiffening and reduction of workability.

The marker shall be affixed to the prepared pavement area with sufficient adhesive so as to squeeze out a small bead of adhesive around the entire periphery of the marker. The required amount of adhesive per marker will normally be in the range of 20 to 40 grams.

The sequence of operations shall be as rapid as possible. Adhesive shall be in place and the marker seated in not more than 30 seconds after the removal of the pavement preheat or warm air blast. The marker shall not have cooled more than one minute before seating.

The length of the pavement preheat or warming shall be adjusted so as to ensure bonding of the marker in not more than 15 minutes. Bonding will be considered satisfactory when adhesive develops a minimum bond strength in tension of not less than 1.3 N/cm² or a total tension strength of 130 N.

Markers shall be spaced and aligned as shown in the Plans and as specified by the Engineer. A displacement of not more than 1 cm left or right of the established guideline will be permitted. The contractor shall remove and replace at no expense to the owner all improperly placed markers.

Markers shall not be placed over longitudinal or transverse joints in the pavement surface.

On roadway sections which are not open to public traffic, the preheating of the markers by dry heating before setting will not be required provided the adhesive develops the required bond strength of 1.3 N/cm² in less than three hours. If the roadway section is carrying public traffic during the installation of the markers, the 15 minute set-to-traffic provision will be enforced, and necessary flagging and traffic control will be required. In this case markers shall be protected from all traffic for at least 3 hours after placement.

1100.10.8 Vertical Road Markers (Delineators)

1100.10.8.1 General – Vertical road markers or (delineators) shall be provided at locations shown on drawings and as required by the Engineer.

1100.10.8.2 Type of Delineators - Delineators shall be of the types shown on drawings. Delineators specified under this contract shall be of the following types:

- a. J3
- b. J4 mounted on double post
- c. J5 mounted on single post
- d. J6 mounted on single post
- e. J6 mounted on barrier

All above types of delineators shall conform to the requirements of LIBNORD (Lebanese Norm), mainly but not limited to, NL 375:2000, NL 365:200, NL, 376:200, and NL 377:2000.

1100.10.9 Measurement

Measurement of markers will be by unit (number) for each type of marker furnished and set in place.

1100.10.10 Payment

Payment will be made for each of the following bid items that are included in the proposal:

- a. “Raised Pavement Marker Type 1”, per unit (number).

- b. “Raised Pavement Marker Type 2”, per unit (number).

The unit contract price per unit (number) for “Raised Pavement Marker Type 1”, and “Raised Pavement Marker Type 2” shall be full pay for all labor, materials, and equipment necessary for furnishing and installing the markers in accordance with these Specifications.

- c. Vertical markers (delineators).

The unit contract price per unit (number) for vertical markers (delineators) shall be full pay for all labor, materials, and equipment necessary for furnishing and installing the markers in accordance with these Specifications.

1101-TRAFFIC SIGNS AND SIGN BOARDS

1101.1 Scope

- a. This item shall consist 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/or as directed by the Engineer.
- b. This work shall consist also of furnishing and installing permanent regulatory overhead signs mounted on steel structures.

1101.2 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. Approval of material shall be obtained by the Contractor before ordering any traffic signs.

1101.3 Materials

a. Concrete Bases (for Road Signs)

Sign base dimensions shall be as shown on the detail drawings. Concrete shall be in accordance with the requirements of Section 3.01 of the Specification using 2.5cm maximum aggregate size. The quality shall be that of reinforced concrete.

b. 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/sq.cm.

c. Ordinary and Break-Away Posts (for Road Signs)

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 grammes per square meter.
- aluminium in the form of drawn tubes complying with grades 6063 – TF or 6082 – TF of BS 1471 or bars or extruded tubes or sections complying with grades 6063 – TF or 6082 – TF of BS 1474

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.

d. Sign Plates

Sign plates shall be constructed from one or more of the following materials: -

1. Sheet aluminium and sheet aluminium alloy of minimum thickness 3.0 mm for unstiffened signs or 2.5 mm for bent- edged stiffened signs
2. Extruded aluminium and extruded plank sections complying with grades HE-9TF, HE9-TE or HE 30-TF of BS 1474

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.

Sign plates shall be non-porous, smooth, flat, rigid, weatherproof and shall not rust or deteriorate. They shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of 30 mm for road signs and 100 mm for overhead signs. Any trade mark or other printing shall be carefully removed with a lacquer thinner.

1101.4 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 trade mark 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 certificate of compliance listing its detailed specifications and identifying the standards to which it complies (ASTM D-4956 or approved equivalent)
- b. The base of the sign shall be normally of white, blue or yellow wide angle high intensity reflective sheeting or as described in the foregoing paragraphs, but the particular sign message shall be indicated on the Drawings.
- c. Prior to application of reflective film, the signs shall be cleaned and shall be waxfree. They shall be greased by vapor 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 any standard method by a band saw or a 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 colors reflective 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 color or its reflectivity, nor shall it deteriorate in any way.

- h. The backface of the sign plate shall be painted with medium gray color so that the life of the two faces remains the same, i.e. 10 years.

1101.5 Lettering

- a. Sign lettering shall be in clear open upper case 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.

1101.6 Location of Signs

Signs are located as shown on the plans. These are tentative locations subject to field adjustments by the Engineer. No sign shall be erected prior to the Engineer’s final approval of the location.

1101.7 Existing Signs

Where shown on the plans 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.

1101.8 Sign Removal

Where shown on the plans 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 (usually the local municipality) and shall be stockpiled, as specified by the Engineer, at the location designated by the owner. The Contractor shall dismantle all signs in such a manner as to leave them in a reusable condition.

1101.9 Sign Replacement

Where shown on the plans or ordered by the Engineer after his revision of the existing sign messages or layouts, the Contractor shall remove and reinstall portions of 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 aluminum blind rivets painted the same color 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.

1101.10 Sign Relocation

Where shown on the plans or as directed by the Engineer, the existing signs and, if so indicated, the sign structures shall be relocated by the Contractor to the location noted. 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. Where the existing structure is to be relocated, the Contractor shall provide necessary materials, labor, and hardware, so as 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.

1101.11 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 must be properly located and should be faced slightly towards the road.
- c. To avoid specular glare, the sign face should be titled back two or three degrees (about 1 cm per 26 cm of sign height).
- 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 material shall withstand a wind load of 150 kg per square meter 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 color 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, which will permit 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 excavation shall be cleaned and cut to a first surface prior to the placement of concrete base. Approved backfill material shall be used. The adjacent surface shall be neatly graded and compacted.

1101.12 Guarantee by Contractor

- a. All signs shall be guaranteed by the Contractor against any defect in material and workmanship for a period of 2 years 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 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 on this Contract or any other Contract as the Employer may decide.
- 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 may also be assessed at any other time during the Defects Liability Period to ensure conformance with manufacturers specifications. The Contractor shall provide assistance in terms of traffic management provision and the provision of support labour, testing equipment and materials for the duration of testing when requested by the Engineer.

1101.13 Temporary Signing

1101.13.1 Temporary signing shall include, but not limited to, the following signing stated in the Contract Documents:

- a. Barricade with flashers, type K5C.
- b. Rectangular sign, type KC1.
- c. Sign, size less than or equal to one square meter but less than or equal to two square meters including posts, supports, foundations and all related works, type KD2, KD8, and KD5.
- d. Sign, size greater than one square meter including posts, supports, foundations and all related works, type K2.

1101.14 Temporary Channelizing Devices

1101.14.1 Temporary channelizing devices shall include, but not limited to the following devices as stated in the Contract Documents:

- a. Plastic Barrier, 145cms long and 40cms wide, type K16.
- b. Removable single face concrete safety barrier, 200cms long and 38cms wide.

c. Removable double face concrete safety barrier, 200cms long and 60cms wide..

1101.15 Gantry Structures

1101.15.1 Gantry structures shall be designed by the Contractor and submitted for the Engineer's approval including calculations, shop drawings and any other necessary information required by the Engineer. Design shall be made in accordance with Specifications "Section VIII – Structural Steelwork".

1101.16 Measurement and Payment

1101.16.1 Regulatory, Warning, and Indicator Signs

1101.16.1.1 Measurement - Measurement shall be made by the number of signs installed whether post with single sign panel or double sign panels or road sub-signs ($<0.2\text{m}^2$).

1101.16.1.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include sign face, sign panel, posts, breakaway connections, painting, earthwork, foundations, fixings and all materials, labour, equipment and other items and work necessary to complete the works.

1101.16.2 Directional Signs

1101.16.2.1 Measurement - Measurement shall be by the meter square of the face area of the panels.

1101.16.2.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include, sign face, sign panel, posts where applicable, painting, breakaway connections, earthworks, foundations, fixings and all materials, labour, equipment and other items and work necessary to complete the works.

1101.16.3 Temporary Signs

1101.16.3.1 Measurement - Measurement shall be made by number for each type separately, whether post with single sign panel or double sign panels or signs less than 1m^2 or greater than 1m^2 , but less than 2m^2 .

1101.16.3.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include sign face, sign panel, posts as required, breakaway

connections, painting, earthwork, foundations, fixings and all materials, labour, equipment and other items and work necessary to complete the works.

1101.16.4 Temporary Channelizing Devices

1101.16.4.1 Measurement - Measurement shall be made by number for each type separately. Signs with post shall be measured by number whether post with single sign panel or double sign panels, stating the size of signs whether less than 1m², or greater than 1m² but less than 2m².

1101.16.4.2 Payment - Payment shall be made at the rate indicated in the Bill of Quantities which rate shall include sign face, sign panel, posts, breakaway connections, painting, earthwork, foundations, fixings and all materials, labour, equipment and other items and work necessary to complete the works.

1101.16.5 Gantry Signs

1101.16.5.1 Measurement - Measurement shall be by the meter squared of gantry structures signs installed for each nominal span separately.

1101.16.5.2 Payment - Payment shall be made at the rates indicated in the Bill of Quantities which rates shall include all structural elements, protection, fixings, connections, painting and all materials, labour, equipment and other items and work necessary to complete the works.

1101.17 Rumble Strips

-Rumble strips shall be made of thermoplastic materials in conformance with the applicable Sub-clause 1100.02 or 1100.03 above. Rumble strips shall be applied to the required details of applicable code and standards. Rumble Strips shall have a thickness of not less than 25mm thick and in accordance with the recommendations of the manufacturer.

-A testing certificate from an approved third party testing agency shall be submitted to the Engineer to confirm that materials meet all requirements specified.

-Before applying thermoplastic materials on Asphaltic concrete surfaces, a primer sealer shall be applied in accordance with the manufacturer.

Rumble Strips shall be of the “Raised Rumble Strips Type” and of a thickness not less than 25mm. Apply raised rumble strips having well defined edges. Remove and replace any raised rumble strips not meeting the requirements specified and approved manufacturer’s recommendations at no additional cost.

Before applying raised rumble strips, remove any material that would adversely affect the bond of the raised rumble strips by a method approved by the Engineer.

Apply raised rumble strips only to dry surfaces, and only when the ambient air and surface temperature is at least 55°F [13°C] and rising.

1101.7.1 Method of Measurement:

Rumble Strips shall be measured in square meter. The area measured shall be that limited by the external edges of the two strips laid at the two opposite extreme ends of an applied rumble strips set.

1101.17.2 Payment - Payment shall be made at the rate inserted in the Bill of Quantities which rate shall include for all thermoplastic materials, primer or sealer as required, labour, equipment and other items and work necessary to complete the works.

****END OF SECTION****

SECTION – XII
OUTDOOR LIGHTING, MV/LV AND TELEPHONE NETWORKS

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SECTION – XII

OUTDOOR LIGHTING, MV/LV AND TELEPHONE NETWORKS

1200 – OUTDOOR LIGHTING

1200.01 Scope - This section contains the materials, equipment and construction requirements for road lighting network.

1200.02 Standards and Codes - The following standards and codes in their latest edition shall be particularly applied to works covered by this Section.

ASTM

A 123	Zinc (Hot Galvanised) Coating on Products Fabricated From Rolled, Pressed and Forged Steel Shapes, Plates, Bar and Strip
A 153	Zinc Coating (Hot Dip) on Iron and Steel Hardware
A 307	Carbon Steel Externally and Internally Threaded Standard Fasteners
A 385	Providing High Quality Zinc Coatings (Hot Dip) on Assembled Products

AASHTO

Standard Specification for Structural Support for Highway Signs, Luminaries and Traffic Signals

BS

BS 159	Busbars and Busbar Connections
BS 729	Hot Dip Galvanised Coating on Iron and Steel Articles
BS 2989	Hot Dip Zinc Coated Steel sheet and Coil
BS 3971	Miniature and Moulded Case Circuit Breakers.
BS 4360	Weldable Structural Steels
BS 4533	Sections - Road Lighting Lanterns
BS 4660	Unplasticised PVC Underground Drain Pipe and Fitting
BS 4678	Cable Trunking
BS 4752	Specification for Circuit Breakers (Switchgear and Control Gear for Voltages 1000 V AC)
BS 5972	Photoelectric Control Units for Road Lighting
BS 6360	Conductors in Insulated Cables and Cords
BS 6469	Insulation and Sheaths of Electric Cables
BS 6500	Insulated Flexible Cable
BS 6746	PVC Insulation and Sheath of Electrical Cables

CEE

26	Rigid PVC Conduit and Fittings
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CIE

Publication No.30 (TC-4.6) 1976

Publication No.30.2 (TC-4.6) 1982

IEC

60158 Low Voltage Control gear - Part 1

60228 Conductors of Insulated Cables

60529 Classification of Degree of Protection Provided by Enclosures

60540 1970 Tests

60598 Luminaires

Materials and equipment not complying with the requirements of the above standards and codes shall not be approved by the Engineer.

1200.03 Definition of Terms -The following are definitions of terms as used in these Specifications:

Bonding jumper - A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Bracket - A component used to support a lantern at a definite distance from the axis of the lower straight portion of a column of single or double form and demountable from the column.

Bracket Projection - Horizontal distance from the joint of entry of the bracket to the lantern to a vertical line passing through the centre of the cross-section of the column at ground level

Clamp - A gripping device for connection of conductors for cable jointing.

Control Cabinet - An enclosure designed for surface mounting and provided with a frame in which swinging doors are hung and where circuit protective devices are installed.

Feeder Pillar (As Control Cabinet)

Flange Plate - A plate with an opening for cable entry welded to a column which is surface mounted to allow it to be secured to a concrete foundation or to other structures.

Frame - A frame is an assembly consisting of all parts of the circuit breaker except the trip unit and the terminal connectors.

Glare - The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort or loss of visual performance and visibility.

Lighting Unit - The assembly of light pole and lantern.

Lowering Device - A device used to lower a high mast lantern to a convenient distance above ground level (1.0 m maximum) for ease of inspection and maintenance.

Luminaire (or Lantern) - A complete unit consisting of lamp or lamps & control gear, together with the parts designed to distribute the light, to position and protect the lamps and to connect the lamps to the power supply.

Luminance Uniformity - The overall uniformity is defined as the ratio L_{min} / L_{ave} . In the determination of this value, " L_{min} " is to minimum local luminance and " L_{ave} " the average luminance of the whole carriageway, both seen from an observation point a quarter of the width of the carriage way from the rightside kerbline.

The longitudinal uniformity is considered for each driving lane and is the ratio L_{min}/L_{max} along the centre line of each lane assuming that the observation point is placed on the centre-line. The longitudinal uniformity is determined from the calculated luminances.

Mounting Height - The vertical distance between the road surface and the centre of the apparent light source of the lantern.

Spacing - for road lighting the distance between successive lighting units, measured along the centreline of the road.

1200.04 Materials - All materials and equipment shall comply as a minimum with:

- a. The latest relevant recommendations of the International Electrotechnical Commission (IEC) if available.
- b. If a. is not available, with the latest relevant British Standard Specifications (BS).

This applies to quality of material, manufacture and testing. If standards as mentioned above conflict with these Specifications, than the requirements of these Specifications shall apply.

All materials used shall be brand new and the best of their respective kind and the most suitable for working under the weather and site conditions set out in these Specifications, thus withstanding the variations of temperature and other prevailing conditions without distortion or deterioration of any adjacent part.

The equipment included in these Specifications shall be so manufactured as to facilitate easy and proper erection and maintenance. The design of all equipment shall ensure satisfactory operation under the site conditions mentioned.

All terminal blocks for cable terminations shall be of the high temperature type, i.e. suitable for use at a minimum operating temperature of 90°C and in the case of cut-out box assemblies they shall be of the polycarbonate type.

1200.05 Workmanship - The workmanship of all parts shall be of the highest order and defective parts shall not be welded, plugged or filled in without the written permission of the Engineer. Metal works shall be adequately protected against corrosion and oxidation bearing in mind the site conditions mentioned. Corresponding parts shall be made to gauge and shall be interchangeable wherever possible throughout the Contract works and the Contractor shall prove interchangeability as and when requested by the Engineer. All screws and bolts which will be required to be removed and replaced for maintenance operations shall be of the captive type.

1200.06 Service Connection - This work shall consist of obtaining service connection to the control cabinet location indicated on the Drawings.

The Contractor shall be responsible for making the necessary arrangements with the Electricité Du Liban (EDL) for the connection of the to the power supply network.

All regulations of the EDL shall be strictly observed in the distribution and use of the supply. Under no circumstances shall any installation be connected to the mains supply until authorized by the Engineer.

It shall be Contractor's responsibility to ensure phase balancing throughout the system before connection to the network.

1200.07 Site Conditions - Climatic conditions in Lebanon are as follows: ambient shade temperature can rise to 45°C. with a drop to -6°C during the night in the winter. Periods of high humidity are common and a relative humidity of 100% at 30°C has been recorded. Equipment, poles & luminaires shall be designed to withstand wind speed of 161 km/hr. The equipment and materials required under these Specifications shall give continuous and trouble-free service under the conditions mentioned herein.

The cables will be laid partly in ducts or concrete trenches or trays and partly buried in the ground at a depth of 750 mm cover.

The cables called for in these Specifications shall give trouble-free service under the worst conditions encountered and shall carry their rated currents continuously under the temperature conditions which prevail in summer and shall also withstand maximum fault currents without damage or deterioration.

All equipment supplied under this Contract shall be suitably derated to carry the full load circuit currents under the temperature and environmental conditions applicable to their location in the Works.

1200.08 No extra compensation will be allowed to the Contractor for any expense incurred because of delays, inconvenience or interruptions to his work resulting from compliance with the requirements imposed by this specifications.

1200.09 Examination of the Site - The Contractor shall examine the site of the work in accordance with the Conditions of Contract to determine all work included under this Contract and all conditions to be encountered in performing the work under this Contract.

The Contractor, prior to the commencement of his work shall notify the Ministry of Post Telecommunications and EDL of his intent to perform this work. The Contractor shall coordinate with the statutory authorities to locate & interface with existing services. The Contractor shall report any known or suspected damage to any electrical and telephone facilities immediately to the Engineer. This shall in no way relieve the Contractor of his responsibility for the repair or replacement of facilities damaged by his operations.

In the event of damage to any facilities through the Contractor's operations, the Contractor shall restore the system to operation immediately. The repair or replacement of damaged equipment shall be to the approval of the Engineer.

All damaged cable shall be replaced in complete lengths and all joints shall be in locations permitted in the original installation. No extra compensation shall be allowed to the Contractor for compliance with these requirements or for any expenses incurred to effect repairs to damaged electrical or telephone or other facilities.

1200.10 Control of Approval of Materials - These Specifications govern the procedures for documentation and approval of all materials and equipment proposed for the lighting and electrical works in this Contract.

The Contractor shall conduct his own search into the timely availability of the specified equipment and materials and shall ensure that all equipment and materials are in strict adherence to these Specifications.

All cost of work and materials, including samples, required for satisfying these Specifications shall be included in the rates given in the Bill of Quantities and no additional compensation shall be allowed to the Contractor for any incidental costs that may occur in fulfilling the requirements of these Specifications.

All the required items as specified herein for each of the various submission stages shall be compiled by the Contractor and submitted to the Engineer at one time. A letter enumerating the submitted items shall accompany the submittal package. Partial or sporadic submittals will be unacceptable and the Engineer will return such incomplete submittals unmarked except that under justifiable and extenuating make partial submittal.

All the required drawings, technical data and design computations, together with the duly completed Submittal Schedules required by the Contract Documents, shall be presented in an academic and professional manner in the English or French languages.

Formulae and substituted numerical values shall be clearly shown. Computer print-outs for the computations will be acceptable.

Approval of materials and equipment shall be processed as follows:

- a. Approval Stage A** - Source Approval - within 60 days of the Date of Enterprise the Contractor shall submit for approval by the name of the Manufacturer, the catalogue reference number and full Manufacturer's technical literature for each major item of

equipment to be supplied for the lighting and electrical works in this Contract. The items of equipment shall include, but not be limited to:

- Masts
- Poles
- Lamps
- Joints
- Control Gear
- Cut-Outs
- Miniature Circuit Breakers(MCB)
- Moulded Case Circuit Breakers (MCCB)
- Control Cabinets
- Cables
- Safety Switches

Where items of equipment submitted by the Contractor are not approved by the Engineer, the Contractor shall submit details of alternative equipment necessary supplied by different Manufacturers, until the Engineer's approval is gained.

b. Approval Stage B - Materials Approval - Subsequent to the Source Approval under Stage A and at least 3 months before the Contractors requires to place orders for any materials and/or equipment he shall submit the following for the approval of the Engineer (such approval being subject to satisfactory site performance and operation):

i. General Requirements - A complete list of equipment and materials that are proposed for use together with the Manufacturer's name and catalogue reference numbers and anticipated delivery dates.

The list shall include descriptive literature and technical details and drawings sufficient to fully describe and explain the proposed lighting and electrical system.

ii. Letter of Capacity - Satisfactory evidence that the Manufacturers whose products are being submitted have previously supplied to clients similar lighting units and lanterns to those in the Contract Documents. Evidence of each Manufacturer's production capability shall also be provided. Submissions which do not include such evidence or which include unsatisfactory evidence may be rejected.

iii Submittal Schedules - Fully completed signed copies of all Submittal Schedules required by the Contract Documents including:

- a) Construction Particulars for Light Poles.
- b) Chemical Composition of Steel for Light Poles.
- c) Deviations from Technical Specifications for Light Poles.
- d) Drawing/Catalogues for Lighting Equipment
- e) Technical Schedules and Guaranteed Details for Lanterns for Light Poles.
- f) Guaranteed Technical Particulars for lamps.

- g) Guaranteed Lighting Details for Gantry and Bridge Mounted Sign Lanterns.
- h) Guaranteed details for Lanterns for Underpasses.

iv. Electric Cables

- a) Dimensioned drawings showing the details (including a cross-section) of each and every size of cable annotated to show the make-up of the cables.
- b) Independent laboratory test certificates in respect of Cables

v. Conventional Lighting Poles (Height 20 m and less)

For each pole height and/or mounting configuration:

- a) General dimensions of all component parts.
- b) The total maximum moments, the section modulus required and the section modulus furnished at the base of the pole and at the door openings; and at 6 meters internal along the pole as not applicable.
- c) Computation of stresses in the flange plate, connection attachment and anchor bolts and at the door openings in the pole.
- d) Maximum deflection at the top of the pole under load conditions and gust wind velocity 160 km/h.
- e) All calculations shall be for the poles equipped with the lanterns proposed by the Contractor.

Additionally for hinged poles only:

- f) Full details of the construction and method of operation.
- g) Working drawings of the proposed hinge mechanism.

All calculations shall be for the poles equipped with the lanterns proposed by the Contractor.

vi. Performance Standards

To allow an assessment of the most suitable and efficient lighting unit to be made the Contractor shall submit a table of the number of lighting units required for each separate lighting system (i.e. every luminaire/mounting height combination) to illuminate one kilometre of straight motorway or roadway for the relevant Roadway Designation.

vii. Manufacturer's Literature and Technical Data

Complete Manufacturer's specifications and detailed technical literature, dimensioned drawings, data, etc., of the masts, poles, raising and lowering systems for high mast units, lanterns, lamps, control gear (chokes, capacitors, ignitors), wire, cables, cable joints, conduits, trunking ducts, junction boxes, cut-outs, circuit-breakers, switchgear, photo-cell and time-switch controls,

control cabinet equipment and all other equipment for the Works under these Specifications. Manufacturer's catalogue numbers of adhesives, tape and miscellaneous items shall be listed.

viii. Shop Drawings

Shop drawings for the fabrication of the control cabinets, the parts thereof and the wiring of the equipment therein and shop drawings of the mast and pole shafts and arms, showing in detail the fabrication thereof and the description of any materials used in the fabrication, anchor bolts and foundation reinforcing materials.

ix. Isolux diagrams of horizontal illumination, utilisation curves and isocandela diagrams for the proposed lanterns

1200.11 Inspection and Testing - The equipment covered by these Specifications may be subject to inspection during manufacture. The inspection will be carried out by an Inspector appointed by the Employer and the Contractor shall provide all necessary facilities for the Inspector who may carry out or witness any tests that may be deemed necessary. All required materials for the inspection and testing as well as all testing equipment shall be supplied by the Contractor and included in the Contract price. The Contractor shall carry out all tests specified in the latest relevant CIE/IEC/BSS specifications and these shall also witness luminance and illumination tests on the lanterns to ensure that the levels of luminance, illumination, uniformity ratios and other data guaranteed at the time of tendering are actually obtained.

Shipment of materials and equipment shall not be effected unless the Inspector's release note is obtained. No release note issued by the Inspector shall relieve the Contractor from his liability to supply equipment or exonerate him from any of his guarantees according to these Specifications and the accepted submittals.

All joints, taps and ground connections shall be inspected by the Engineer before the wires and cables are permanently trained in handholes, junction boxes, conduits, or light poles.

After the installation has been completed, current, voltage and insulation resistance readings for each circuit shall be taken and tabulated by the Contractor. Any indications of ground fault which are a result of work performed by the Contractor shall be thoroughly investigated and remedied before final acceptance of the installation. Insulation resistance readings shall meet the approval of the Engineer. Lamp terminal voltages shall be taken at the locations designated by the Engineer. Three copies of the tabulation of voltages, current and insulation resistance showing before and after readings for each branch circuit shall be submitted to the Engineer.

1200.12 Field Performance Tests - Prior to completion of the Work, all electrical circuits and lighting systems shall be checked by the contractor to the satisfaction of the Engineer. Each circuit shall be tested for continuity and for ground. A megohmmeter test shall be made on each circuit between the circuit conductor and a ground. The insulation resistance shall not be less than ten megaohms at a test level of 1000 volts and the readings shall be recorded and furnished to the Engineer.

Measurements of Luminance shall be made at the positions indicated. The Contractor shall provide all necessary equipment (including all test meters) and shall measure and record values of luminance and illuminance in accordance with the recommendations of Publication CIE No.30.2 (TC-4.6) 1982. These measurements shall be witnessed by an Inspector appointed by the Employer, who may require demonstration of the accuracy and reliability of any instruments used. Calibration Certification for all measuring equipment shall be presented to the Engineer for approval before any field tests are undertaken.

A functional test shall be made to verify that every part of the system functions as required by the Drawings and these Specifications. The length of the functional test shall consist of not less than five nights of continuous satisfactory operation. If unsatisfactory performance of the system develops due to faulty materials, fabrication or installation, the condition shall be corrected and the test repeated until five nights of continuous satisfactory performance is achieved. Any components of the lighting system found to be faulty, malfunctioning or damaged during the test period shall be removed and replaced at the Contractor's expense.

During the five nights test period, the Contractor's maintenance crews shall maintain the system or systems undergoing test. The costs of any maintenance necessary except electrical energy and maintenance due to damage by public traffic shall be at the Contractor's expense and no additional compensation shall be allowed. The functional test for each road lighting system shall consist of an operational test for five consecutive nights according to the regular lighting schedule. Shut-down caused by factors beyond the Contractor's control shall not constitute discontinuity of the functional test.

The Contractor shall provide hand tools for the use of the Engineer.

1200.13 Voltage System - System - System Values shall be as follows:

a. For roadway lighting:

380 / 220 volts \pm 6 %, 3 phase, 4 - wire and earth, 50 Hz,
Solidly earthed neutral at the power transformer.

1200.14 Setting out - The Contractor shall set out the lighting and electrical works accurately on site and in relation to all existing, relocated and new utilities and services before he commences any installation or erection. With the approval of the Engineer the Contractor shall make minor adjustments to the location of lighting masts, light poles, control cabinets and lighting cable runs to avoid or minimise conflicts with underground cables, utilities, conduits, pipes, ducts or other services.

Any minor adjustments made shall not affect the validity of the guaranteed performance submittals made under these Specifications.

No extra compensation will be allowed to the Contractor for any expenses incurred because of delay, inconvenience or interruption to his work resulting from compliance with the above requirements.

1201 – TRENCH AND BACKFILL

1201.01 General - This work shall consist of constructing trenches for the accommodation of the electric cable or ducts and backfilling at the locations shown on the Drawings. The Contractor shall include the furnishings of the backfill material and disposing of surplus material.

1201.02 Construction Methods - The trench shall be excavated in a manner to prevent cave-ins and to a depth of not less than 750 mm. Excavated material shall be deposited at a sufficient distance so that the excavated material cannot fall back into the trench. The width of the trench shall be at least 200 mm. Where the electric cable enters the light pole foundation or conduit or other pipe, the bottom of the trench shall be built up to provide a smooth bed for the electric cable.

The electric cable shall be placed in the bottom of the trench after all loose stones have been removed and all protruding stones have been removed or covered with backfill material as directed by the Engineer.

The backfill material shall be thoroughly compacted to a density equal to the existing ground or as approved by the Engineer in such a manner as not to injure the electric cable.

No stone or rock greater than 50 mm in maximum dimensions shall be allowed in any layer of backfill.

Suitable material excavated from the trench may be used as backfill.

The Engineer shall inspect:

- a. The trench before the electric cable or conduit is placed in the trench.
- b. The trench at any other time during excavation or back filling, the method and type of equipment to be used in compacting the backfill material and shall be approved by the Engineer before any work is started.

1202 – FOUNDATIONS FOR LIGHT POLES

1202.01 Foundations for Lighting Poles - This work shall consist of the construction of reinforced concrete foundations for lighting poles in accordance with the Drawings and these Specifications, or in accordance with poles manufacturers recommendations which may be substituted with the approval of the Engineer. Foundation for lighting poles shall be cast in situ.

For all foundations, the number of anchor bolts, bolt circle diameter, anchor bolt dimensions and flange plate material shall be such as to withstand the loading described elsewhere on the Drawings and in these Specifications. The projecting portion of the anchor bolt and the nuts and washers shall be treated by the hot dip-galvanising method in accordance with ASTM

153 or other such protective system as may be approved by the Engineer. The conduit for all poles shall consist of approved by the Engineer. The conduit for all poles shall consist of two 75 mm outside diameter UPVC conduit.

The foundations shall be cast-in-situ and allowed to cure for at least seven days before the light pole is erected. Concrete shall be deposited against the soil. If soil conditions required the use of a liner to form the hole, the liner shall be withdrawn as the concrete is deposited. Forms shall include templates to hold anchor bolts and conduit secured in proper place during the casting of concrete.

1202.02 Special Foundations -Where special foundations are required to avoid conflict with other utilities, full design proposals and structural calculations shall be submitted for the Engineers approval.

1203 – ELECTRIC CABLES

1203.01 Materials, Armoured Electrical Service Cables - all Cables used shall be PVC/SWA/PVC, 600/1000 Volts unless otherwise indicated.

Note: Cables are to be supplied in 500 m non - returnable drums.

1203.02 Electric Flexible Cables, 300/500 Grade - The flexible cables specified here are required for the installation inside the steel street lighting poles where the temperature and humid conditions are extreme and severe.

The flexible cords shall be PVC insulated, PVC sheathed, 300/500 volts, circular, 3-core, with copper conductor and shall comply with Table 16 of BS 6500: 1984, except that the insulation and sheathing shall be to type 4 of BS 6746: 1976. The flexible cable cross section shall be at least 2.5mm^2 , with a maximum unvoltage drop between cut-out & lasstern, not to exceed 0.5V.

The flexible cords shall be tested in accordance with BS 6500: 1984.

The flexible cords shall be supplied in 100 m non-returnable reels.

Cables conforming to comparable international standards may be considered by the Engineer. All single core applicable BS or IEC tests shall be performed on the cable at the manufacturer's plant and certified test results shall be submitted to the Engineer with each shipments of any material to the project site.

1203.03 Packing - All underground cables shall be delivered to site wound on strong wooden cable drums provided with wooden battens to protect the cable from damage or in such other containers as may be approved by the Engineer. Other cables shall be delivered to site on alternative drums approved by the Engineer.

Except where the exact length of cable is marked on the outside of the cable drum or container the length of cable shall not vary from the nominal length by more than 2%.

1203.04 Markings - All cable drums shall be clearly engraved as follows:

- a. Name of Manufacturer
- b. Sizes and number of conductors
- c. Voltage
- d. Drum number
- e. Weights - net and gross
- f. Direction of rotation
- g. The "A" and "Z" ends of the cables to indicate the lay of the cable cores.

1203.05 Technical Requirements and Specifications

1203.05.1 Conductors - The conductors shall be stranded copper conductors in accordance with IEC 60228. They shall be of circular shaped cross-section.

1203.05.02 Insulation - Sheath and Insulation shall consist of extruded PVC and shall withstand deterioration while in the storage and service conditions. The PVC used for the sheath shall be to Type 9, Table 1 of BS 6746.

1203.05.03 Laying- Up - The cores of the cables shall be laid with a right hand direction of lay. Where necessary, non-hygroscopic fillers, which may be applied integrally with the sheath of the cables, shall be used to form a compact and circular cable. There shall be no adhesion between the sheath is applied integrally with the fillers it shall be possible to strip it from the cable without damaging the insulation of the cores.

1203.05.04 Current ratings - The Current ratings of cables for the site and installation conditions mentioned above shall be stated.

Where ratings are specified for any standard conditions appropriate adjustment factors shall be stated.

1203.05.05 Short Circuit Ratings - Short circuit current curves shall be submitted. It is to be assumed that the conductor is at its maximum operating temperature of 90°C before the occurrence of the short circuit. The magnitude of the short circuit current in the conductor for the maximum duration of 0.5 second shall be limited by a maximum conductor temperature of 200°C.

The formula used in evaluating the short circuit current shall be stated.

1203.05.06 Guarantee - A guarantee certificate shall be submitted to guarantee that the offered cables particularly the outer PVC sheathing shall withstand the severe ambient climatic conditions when stored on their drums.

1203.05.07 Tests - The insulation and sheath of the cables shall be tested in accordance with IEC and/or British Standard.

Measurement of thickness and weight sample tests shall be carried out as follows:

One metre length of cable cut from 10 % (or at least one drum) of each of the different types and sizes of drums of cables - selected at random.

The minimum and average thickness of insulation and sheathing shall be determined and these shall agree with the guaranteed values. Also the weight of copper per metre of cable shall be determined.

All cable lengths cut and used for the various tests shall be to the Contractor's account and these not affect the final length of cable to be supplied as specified.

1203.06 Jointing 600/1000 Volt Cables - This Clause covers the use of cable jointing kits employing cold-pouring, solid-setting resin, which are suitable for direct burial in the ground, Underground joints will be avoided whenever possible by looping cables in and out of lighting poles, but where shown as necessary on the Drawings these joints shall be made by skilled cable jointers using plastic joint box kits of an approved type filled with cold-pouring resin and approved mechanical connectors.

Joints employing sweated or compressed connections will not be approved.

Jointing kits shall contain the complete set of materials required to make the joint on site, including:

- a. Two part casing, either transparent or with filler hole large enough to inspect all clearances.
- b. Casing sealing materials.
- c. Resin and hardener, which during setting shall not exceed the maximum permissible temperature for continuous operation of the cable.
- d. Conductor mechanical connectors suitable for the maximum current rating of the cable to be jointed.
- e. Conductor insulating material.
- f. Earth/armouring continuity strap and clamps.
- g. Complete and easy-to follow instructions.

The Contractor shall give adequate notice and shall provide facilities for the Engineer to inspect each joint both before filling and before burying.

Splicing will not be accepted as a way of jointing cables. Only approved clamping devices shall be used.

A minimum length of 500 mm of additional cable shall be provided adjacent to each joint on both the incoming and outgoing cable runs to allow for future remaking of the joint in the event of damage.

1203.07 Cable and Cord Terminations - All terminations of all cables and flexible cords shall be mechanically and electrically sound. They shall be protected against

mechanical damage and shall securely contain and anchor all the wires of the conductor without imposing any mechanical strain on the cable or cord or on the terminal.

Terminations shall be insulated for the full voltage of the circuit of which they form part. Where the design of the terminal is such that live parts are exposed, such parts are exposed, such parts shall be shrouded to prevent accidental contact with them. Terminals on a common board or block shall be separated from each other by barriers which increase creepage distance and reduce the possibility of short circuits. Terminals shall be located or shielded so that if one wire of a stranded conductor escapes from a terminal when the conductor is fitted, the loose wire cannot make accidental contact with any other metal part.

Insulation shall not be stripped back further than is necessary to make a sound electrical connection. The sheath of multicore cables shall not be stripped back further than is necessary to allow the separate cores to reach their corresponding terminals. Where cable glands are used they shall securely retain the outer sheath or armour of the cable without damage.

Where the cable is terminated in a lug a sleeve shall be provided over the end of the insulation and the barrel of the lug to provide additional support and prevent excessive bending of the wire where it enters the barrel of the lug.

Terminations shall be capable of carrying the full load current of the circuit of which they form part without a significant voltage drop across the termination or appreciable heating of the termination. The contact resistance shall not exceed 0.001 ohm.

For lanterns the terminations shall be enclosed in heat resistant non-flammable silicon, glass fibre or other approved insulating material.

The termination shall clamp the conductor between metal surfaces with sufficient contact pressure to ensure a good electrical connection but without damaging the conductor. Screws shall have at least two full threads in engagement when clamping a conductor. The fixed part of the terminal shall be secured against rotation which may occur when the clamping means are tightened or loosened.

Connections in which the bare conductors of two or more cables or cords are twisted together enclosed in a connector made for the purpose or not, shall not be used.

1203.08 Cable Entries (Control Cabinets, Cutout Boxes, Abutment Boxes etc.) - All cable entries into equipment shall be effectively sealed with a compression type cable sealing gland or conduit glands to the approval of the Engineer.

1204 – EARTH BONDING AND GROUNDING

1204.01 General - Metal conduit, non-metallic conduit, grounding wire, ballast, control cabinet, sign switches, anchor bolts and metal poles shall be made mechanically and electrically secure to form a continuous system with all metal components effectively grounded. Grounding jumpers shall be copper wire or copper strap with the same cross-sectional area as 16 mm² for lighting system.

Bonding of light poles shall be by means of bonding jumpers attached to brass, bronze or stainless steel bolts installed in the lower portion of the shaft as shown on the Drawings. Grounding of metal conduit, service equipment and neutral conductor at service points shall be in accordance with details shown on the Drawings. The service equipment enclosure shall be bonded to the ground terminal. Bonding of metallic conduit in concrete handholes or pull boxes shall be by means of lock nuts, one inside and one outside of the box or by threaded bosses or hubs on the boxes.

Ground rods shall be 19 mm diameter and minimum 3 m long. All rods shall be housed in approved handholes fitted with cover and frame of approved make. The tops of the ground rods be a minimum of 450 mm below finished ground level and the rods shall be properly connected to the grounding wire.

The Contractor shall test and prove for all grounded systems that the resistance to earth does not exceed 0.5 ohm. The test shall be done in the presence of the Engineer at a time chosen by the Engineer. The ground rods shall be driven to a sufficient depth to achieve the required low resistance under summer conditions and additional rods shall be used if necessary. Artificial conditions will not be accepted during testing.

Lighting masts 25 m to 40 m high, light poles 22 m high and sign support structures which span the carriageway shall be provided with a separate system of earthing as a protection against lightning. This shall comply with the requirements of BS 6651 1985.

The use of metallic conduit as an earth continuity conductor will not be accepted.

Separate earthing shall be provided for each item of control equipment within lighting poles, each connected to a central earthing point.

The hoisting and power cable sheaves shall be made of stainless steel materials. The groove diameter of the sheaves shall be coordinated with the diameter of the stainless steel hoisting cables and the diameter of the power cable.

The system shall be provided with a circuit breaker of the rating indicated on the Drawings. There shall be a power disconnect receptacle in the mast base. The circuit breaker shall be suitably derated for climatic conditions, such that no further derating will be required.

Means of discharging any accumulated moisture shall be provided at the pole base. When grout is used between the flange plate and the top of the foundation to seal it, provisions shall be made for adequate drainage.

The Contractor shall obtain from the Manufacturer literature stating clearly the type of steel he proposes to use in manufacturer of the lighting masts, the chemical and mechanical properties and all other information required.

The Contractor shall supply a sample length of mast, a minimum 1500 mm long, incorporating the proposed door opening complete with door, gasket, locking device and steel chain, showing a typical weld and being galvanised by the method proposed to be used for the permanent works.

The steel used for the sample shall be of the chemical composition proposed for the permanent works.

1205 – LIGHT POLES

1205.01 General - The poles shall be of high strength structural 4 mm thick steel, hot dip galvanised, one piece conical in shape, cylindrical octagonal cross-section, having a spigot at the top and substantial flange plate at the bottom with a foundation- bolt-frame.

The poles shall be complete in all respects and no welding shall be required at the site at the time of erection.

The poles are to be erected so that the doors on all of them face in the same direction. This direction shall be agreed with the Engineer before erection.

The Contractor shall supply a sample length of pole, a minimum 1500 mm long, incorporating the proposed door opening complete with door, gasket, locking device and steel chain, showing a typical weld and being galvanised by the method proposed to be used for the permanent works. The steel used for the sample shall be of the chemical composition proposed for the permanent works.

1205.02 Dimensions - Pole dimensions shall be as shown on the Drawings.

1205.03 General Requirements - Poles shall have base compartments, with a handhole for housing the cable terminations and service cut-outs. Each door opening shall be 130 mm x 600 mm. The top of the door opening shall be a maximum of 2 m above the bottom of the flange plate.

A ground nut for accommodating a 10 mm diameter threaded bolt or stud shall be provided on the inside of the shaft in a readily accessible position in the base compartment near the bottom of the door opening.

The doors of the base compartment shall be fixed with a substantial locking device. The locking device shall be of a type that opens with an 8 mm Allen key. The Contractor shall provide 8 No. Keys for the locking device. All loose parts of the locking device shall be so arranged that they are held captive on the door when it is in the open arranged that they are held captive on the door when it is in the open position. All the moving parts of the locking device shall be nickel plated. The doors on the base compartment shall be accurately fitted to the door openings ensuring them weatherproof. An approved sealing gasket shall be affixed to each door such that it complies with protection Class IP54 of IEC 60529. Precaution shall be taken to prevent the door being pushed into the pole during transit.

There shall be a galvanised steel chain between the pole and each door to ensure that no door can be lost if incorrectly secured.

The pole shall not have more than one section other than the spigot.

Any minor modifications or additions, which in the opinion of the Engineer are essential to the construction of the pole shall be carried out without any additional cost whatsoever.

During shipment to the site the poles shall be containerised. During storage on site the poles shall be carefully protected to preserve the finish.

The exterior surface of the pole shall be free from protuberances, dents, cracks or other imperfections.

The light poles shall be designed in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signs. The light poles shall be capable of withstanding wind speeds 160 km/hr. Pole thickness shall be such as to comply with the requirements for a compact tube given in the above AASHTO specification. The poles shall be designed assuming that they are fully equipped with the maximum number of luminaires specified with each item being of the maximum weight and windage area and taking into account structural aspects including door openings.

The pole and vertical part of the arm bracket shall be constructed straight.

Suitable tests shall be made on random samples to ensure the above requirements are met. Facilities for these tests shall be provided by the Contractor.

The Contractor shall obtain from the Manufacturer literature stating clearly the type of steel he proposes to use in manufacture of the light poles, the chemical and mechanical properties and all other information required in the Schedules contained in the Contract Documents.

The complete pole unit and appurtenances shall be hot dip galvanised the composition of the steel shall comply with the limitations given in ASTM A385 Clause 3.2.

The flange plate where in contact with the pole foundation shall be coated externally with black bituminous paint.

Means of discharging any accumulated moisture shall be provided at the pole base. When grout is used between the flange plate and the top of the foundation to seal it, provision shall be made for adequate drainage.

All the accessories of the poles shall be greased or enclosed with an approved protection and packed before delivery.

1205.04 Miniature Circuit Breakers - The miniature circuit breakers shall comply with BS 3871: Part 1 and shall have a minimum breaking capacity of 7 KA. The breakers shall be suitably derated for climatic conditions.

All cut-outs shall also be provided with approved type of rubber bushings at the top holes of the cut-outs.

1206 – CONTROL CABINETS/FEEDER PILLARS

1206.01 Materials for control Cabinets/Feeder Pillars - This clause pertains to fabricated electroplated, galvanised or stainless sheet steel control cabinets for the control of lighting installations. They shall be constructed to be fully suitable for outdoor installation (IP54) and shall have adequate dimensions.

Cabinets may be fabricated from electroplated sheet steel protected after fabrication by a two coat (gray) paint treatment approved by the Engineer with a minimum total dry coat thickness of 150 microns. Anti-corrosive paint shall be applied to all welds before painting.

Cabinets may alternatively be fabricated from sheet steel hot dipped galvanised. The construction of the cabinet shall be such as to result in a cabinet free from distortion after galvanising. To achieve this it may be necessary to provide internal bracing to the cabinet walls and doors.

Cabinets fabricated from stainless steel sheet will also be acceptable.

Each control cabinet shall consist of only 1 compartment & shall include an equipment mounting panel, control devices and bus bars, all wired and ready for use. A ventilation system shall be provided incorporating a filter to avoid dust entry into the cabinet.

The compartment doors shall have robust weatherproof hinges and a suitable and substantial lockable latching device. The doors shall be gasketed to provide protection against the ingress of moisture and dust to degree IP54 of IEC 60529. The gasket shall be adequate to maintain this degree of protection.

The roof shall be sloped to shed rainwater. The equipment mounting panel shall be fabricated from 3.5 mm thick sheet steel, drilled and tapped for front mounting of the equipment and (where applicable) shall be hot dipped galvanised after fabrication.

The panel shall be easily installed and removed from the front of the cabinet. All wiring and busbars shall be of a size to handle the rated current of the connected equipment. Busbars that will be exposed shall be insulated.

Main circuit breakers shall have 4 poles and the branch circuit breakers shall be single pole of the voltage and ampere ratings shown on the Drawings and shall be fitted with pressure connectors for the wire size shown on the Drawings.

All ratings of main and branch circuit breakers shall be suitably derated for climatic conditions, as such no further derating will be required.

The Contactors shall comply with IEC 60158-1. The contactors shall have minimum making and breaking capacity in accordance with utilisation category AC3 and shall be suitable for minimum Class I intermittent duty.

The Contactors selected shall be such that all current carrying and live parts shall be properly shielded and it shall not be possible to come into accidental contact with them. All contact

assemblies shall be dust protected. The coils of all contactors shall be suitable for operation at a voltage of 220 V \pm 10 %. In accordance with the drawings contactors may be required to operate circuits which are on full-time or during the night only, the particular function being achieved by the appropriate use of manual switching and photo-electric cell switching of their operating coils.

The photo -electric control switch or cell for the control cabinets shall operate from a supply voltage of 220 volts and be rated for a load of 1000 watts and turn ON shall occur at 40 lux and turn OFF at 80 lux. It shall operate within a -5°C to 70°C temperature range. Units shall have a fail-safe feature so that the lighting remains energized in the event of component failure. The photo-electric control switch shall be housed and mounted either inside the control cabinet or at some specified remote position as indicated on the drawings. When mounted in the cabinet a small compartment shall be provided for mounting the photo-electric control switch and which shall be suitable to allow easy removal of the photo-electric switch in case of cell malfunction. A single pole toggle switch for controlling and by-passing the photo-electric cell and of the rating shown on the Drawings, shall be provided and properly labeled, a time switch shall be provided as a back up for the photocell.

Busbars shall be as indicated on drawings and shall be made of copper flats or round bars complying with BS 159 and shall be covered with coloured PVC sleeving or shall be painted for easy phase identification. An earth or ground bar shall be solidly bolted to the main body of the central cabinet. All busbars shall be shrouded & non-accessible by accident.

All wiring within the control cabinet shall be with PVC insulated copper cables colour coded to the approval of the Engineer for easy phase identification and shall be arranged neatly and firmly attached.

All the wiring leads shall be so arranged to allow current reading with clip-on ammeter in each phase of main incoming and all outgoing circuits.

Branch circuits shall be isolated by means of MCCB's which shall comply with BS 3871 and 4752 and shall be labelled to correspond to the circuit labelling shown on the wiring diagram. A minimum of 2 No. MCCB's to be provided as spares in each cabinet.

A minimum length of 500 mm of additional cable shall be provided adjacent to the cabinet on each cable entering or leaving the cabinet to allow for future reconnections in the event of damage to the cable termination block within the cabinet.

The terminals for the incoming supply cable shall be suitable to receive the size and type of cable to be provided.

The control cabinet compartment shall be insulated on the inside of the sides, back, top and inside of the doors with 25 mm thick fibreglass insulation and the insulation shall be faced on the inside with 1.5 mm thick fibreglass reinforced plastic protective mat. The cabinet shall be provided with a separate gland plate for securing the cable glands for incoming power supply and lighting distribution cables.

A door lock and 4 No. keys shall be provided for each control cabinet installed.

The incoming supply cable shall be provided with gland and termination.

1206.02 Tests - The Engineer reserves the right to require such control cabinet tests in the Manufacturer's place of business as he deems necessary to ensure compliance with these Specifications and to reject the equipment failing such tests.

All lighting control cabinet foundations shall be concrete along with reinforcing bars.

UPVC sleeves shall be provided as detailed on the Drawings for entry of power cables.

The foundations shall be cast-in-place and allowed to cure for at least seven days before the control cabinet is erected.

1207 – CONCRETE ENCASED DUCTS

1207.01 General - This work shall consist of furnishing and installing the concrete encased duct to provide and permit routing of electricity supply cables under the motorway and service ducts in bridge side walks or roads.

The ducts shall be encased in concrete Encasement of ducts shall provide a minimum of 150 mm of concrete in all directions.

The centre line of the duct shall be a minimum of 750 mm below the established grade levels, or as shown on drawings.

1207.02 Ducts for Service Ducts in Bridge Sidewalks - Pipes shall be to BS 4660 or BS 5841 or BS 3505 Class C. Joints shall be suitable for the particular pipe used Pipe shall be of 100 mm internal diameter unless otherwise shown on Drawings. Ducts shall be provided with drawwire each and the ends shall be sealed with removable stoppers.

1207.03 Rigid PVC Duct - The duct shall consist of 100 mm diameter u-PVC underground drain pipe and fittings which shall comply with BS 4660.

1208 – SERVICE CUT-OUTS

1208.01 Light Pole Service Cut-Outs - This Clause covers the manufacturer of light pole service cut-outs.

All materials and equipment shall comply as a minimum with the following:

- a. The latest applicable recommendations of the International Electrotechnical Commission (IEC).
- b. The latest relevant British Standard Specifications (BS).

This applies to quality of material and testing under these Specifications and if the above standards conflict with these Specifications then these Specifications shall take precedence.

Any minor modifications required by the Engineer in the actual construction of the cut-out panel shall be carried out without any additional charges whatsoever.

All circuit breakers shall have an on-off indication labelled ON and OFF. Other symbols will not be accepted.

The terminals of all cut-outs shall be shrouded.

On multi- lantern arrays there shall be a separate cut out for each lantern.

Cut-out ratings shall be 10 Amps for all type of lamp,

1208.02 Type of Cut-Out - The type of cut-out shall be suitable for mounting in the base compartment of the rigid steel poles. The cut-out shall be fabricated from sheet steel, rust proof painted, in colour as approved by the Engineer and shall be constructed so as to prevent moisture running down the cable entering the cut-out. It shall be fabricated in the form of an open-topped box with a lid sealed with a heat resistant gasket.

The cut-out shall consist of a 10 amp miniature circuit breaker which shall be three or one single pole according to the number of lanterns carried by the pole. Terminal blocks suitable for looping in and looping out 4 core 16 mm² PVC/SWA/PVC cables, a neutral block and a ground clamp shall be provided. Two number compression cable glands of moulded plastic impact resistant type complete with intermediate and connection bushes, locknuts and suitable for the size of the cable specified above shall be fitted at the bottom of the cut-out panel.

The thickness of the sheet shall not be less than 1.5 mm and shall be fixed to the hanging, strip within the base compartment. The cover of the cut-out shall be of the removable type and shall be fitted with stainless steel captive screws and stainless steel pins such that it is possible to remove easily the cut-out cover with the cut-out in position in the pole base compartment.

The miniature circuit breaker inside the cut-out shall be fixed vertically in such a way that the entire handle in its lower position shall not be more than 140 mm from the top of the cut-out. The handle of the miniature circuit breaker shall project through a slot of the front cover.

1209 – LUMINAIRES

1209.01 Norms - The luminaire shall comply with the latest IEC norms and BS standards.

1209.02 Mechanical Characteristics - The body shall be made of a single piece of glass fiber reinforced polyester and divided into two (2) completely isolated compartments.

The first compartment shall house the optical system, the second compartment shall contain the electrical accessories and the cable feed terminals.

The optical compartment shall have a degree of tightness of IP 65 with shock resistance of 6 joules and the tightness of the control gear compartment shall be IP54. The access to the optical compartment for the purpose relamoing, shall be done without using any tools.

A neoprene gasket shall be fitted on the frame to insure the tightness of the optical compartment and shall be replaceable without the use of any tools.

The luminaire shall have the possibility to be slipped into an arm of 60, 48, or 42 mm.

The lamp holder shall be adjustable to compensate the tolerance in light source.

The mirror reflector shall be of high purity glazed and anodised aluminium, rigidly fixed to the body and easily replaceable.

1209.03 Electrical characteristics - The electrical accessories shall comply with the relevant IEC norms and B.S standards.

The accessories such as ballast, starters, capacitors, fuses... shall be prewired and preassembled on metallic plates mounted and fixed into the metallic compartment special care shall be taken to allow easy maintenance and quick replacement of the accessories and to minimize the risks of falling.

The cable feed terminals and the earth screw shall be fixed to the metallic compartment and a cable holder shall be mounted near the terminals.

1209.04 Photometric characteristics - The photometric characteristics shall comply with the IEC recommendation.

The optical conception shall allow to adapt the photometric characteristics, the protector shall be made of glass or stabilised polycarbonate and shall have a coefficient of transmission of at least 90 %.

1210 – TELEPHONE NETWORK

1210.01 General Requirements- All materials supplied and works carried out under this section shall be in accordance with MOT (Ministry Of Telecommunication) specifications and requirements.

1211 – FINAL ACCEPTANCE INSPECTION

1211.01 General Requirements - When the Engineer is satisfied that the work is complete, including all testing as specified. As part of this may require tests to be carried out

for final acceptance on any item of equipment, in accordance with the Specifications and the same shall be carried out by the Contractor.

The contractor will be advised of the date of the Final Acceptance Inspection and he shall ensure that all necessary equipment and manpower to enable any testing or required inspection work to be carried out is available.

1211.02 Remedial and/or Additional Work - In the event of any aspect of the lighting and electrical works not being in accordance with the specified requirements the Contractor shall, on the written instruction of the Engineer, carry out any remedial, replacement and/or additional work directed by the Engineer to ensure compliance with the specified requirements. The Contractor shall attend and provide for a further Acceptance Inspection of the remedial, replacement and/or additional work. The Engineer will not accept the lighting and electrical works until all the specified requirements have been complied with.

1212 – MEASUREMENT AND PAYMENT

1212.01 General - In addition to the specific item coverage for the various measurable items, payment at the rates shown in the Bill of Quantities shall be full compensation for furnishing all required materials, assembly and installation, testing, checking performances and all incidental works and components as specified or required to provide a complete installation.

Payment shall be made at the rates inserted in the Bill of Quantities.

1212.02 Trench and Backfill

1212.02.1 Measurement - Subject to the provisions of Clause 1201 hereof, no separate measurement for excavation for cable trenches shall be made.

1212.02.2 Payment - No separate payment for excavation for cable trenches shall be made; this work shall be included in the rates for cables.

1212.03 Electric Cables

1212.03.1 Measurement

a. Cables shall be measured by the metre run along the centre line of the cable between termination points stating the type and size of cable and whether installed above or below ground. An allowance of 500 mm, irrespective of the length actually provided, shall be added to the length of cable for each termination point.

For cables drawn into ducts, ducts are measured separately.

b. Protection of existing cables shall be measured as a separate item for each type of cables.

1212.03.2 Payment

a. For directly buried cables rates shall include supply of cables, installation, excavation in any type of soil including rock, backfilling, compaction, concrete tiles, sand bedding and warning tape, connection, and testing, removal of resulting materials and surplus materials to approved dumping areas.

Rates for cables drawn into ducts shall include the supply, installation, connection, testing, commissioning, cable jointing, cable terminations, and providing flexible conduit where required, complete as shown on Drawings.

b. Rates for protection of existing cable shall include locating, identification and temporary protection of the existing EDL cables, all in accordance with the requirements and in accordance with EDL.

1212.04 Earth Bonding and Earthing

Cable shall be measured and paid for in accordance with the requirements of Clause 1204 of these Specifications.

1212.04.1 Measurement - Earth electrodes shall be enumerated.

1212.04.2 Payment - Rate of Earth Bonding and Earthing shall include for the supply and installation of the electrode, connection, testing and proving resistance and handhole, and commissioning, complete with cover and frame.

1212.05 Pipes and Ducts

1212.05.1 Measurement - Pipes and Ducts shall be measured separately stating the type and size. Measurement shall be by the metre run along the centreline of ducts without deduction for fittings and accessories.

1212.05.2 Payment - Rates for pipes & ducts shall include for supply of pipes/ducts, installation, connection, commissioning of ducts including excavation, concrete encasement, steel reinforcement, backfilling, compaction, protection tiles, warning tape, all couplings, fittings, accessories and fixings, testing, and removal of surplus material to an approved location by the Engineer, all as directed and/or shown on Drawings.

1212.06 Lighting Poles

1212.06.1 Measurement

a. Lighting poles shall each be enumerated stating the height and number of arms.

b. Foundations for poles shall be measured separately by the number stating the height of the corresponding pole.

1212.06.2 Payment

a. Rates for lighting poles shall include, internal wiring, cut-out fuses and terminal block, junction box, fixing brackets, anchor bolts and nuts, corrosion protection, supply termination and necessary accessories.

b. Rates for foundations for poles shall include, dewatering, excavation, backfilling with suitable excavated or imported borrow materials, compaction, removal of surplus materials to approved dumping areas, plain concrete, reinforced concrete, steel reinforcements, anchor bolts, nuts, washers and all necessary accessories.

1212.07 Luminaires

1212.07.1 Measurement - Luminaires shall be enumerated stating the type of lamp.

1212.07.2 Payment - Rates for luminaires shall include, the supply and installation of luminaires including lamp, lamp holder control gear, power factor correction capacitor and all necessary accessories.

1212.08 Substation

1212.08.1 Measurement - Substation shall be enumerated stating the type.

1212.08.2 Payment - Rates for substation shall include, fuses, switches, terminations, reinforced concrete pad, excavation, bedding, compaction, PVC ducts and fixing accessories, and all necessary accessories.

1212.09 Manholes and Handholes

1212.09.1 Measurement - Manholes and handholes, other than handholes of earth electrodes shall be enumerated according to type and size.

1212.09.2 Payment - Rate of Manholes and Handholes shall include for excavation in any type of soil or rock, backfilling, disposal of surplus excavated material, concrete, reinforcement, formwork, cover and frame, ducts, and steel accessories, etc,.. as shown on the Drawings and/or specified by the statutory authorities.

1212.10 Control Cabinets/Feeder Pillars

1212.10.1 Measurement - Control cabinets/feeder pillars shall be each enumerated stating the configuration and/or type

1212.10.2 Payment - Rate of Control Cabinets/Feeder Pillars shall include the cabinets, equipment mounting panel, control devices, bus-bars, internal wiring, arranging service connections with EDL, connections to outgoing cables, reinforced concrete foundation and conduit and expansion.

1212.11 Final Acceptance Inspection

1212.11.1 Measurement - No measurement of the final acceptance inspection shall be made separately and it shall be considered included in the rates of other items included in the Bill of Quantities N0.12- Outdoor Lighting, MV/LV and Telephone Networks.

1212.11.2 Payment - No separate payment shall be made for final acceptance inspection and the cost of all requirements for the final acceptance inspection including the provision of equipment, manpower, carrying out of testing, report writing and reproduction and all other items necessary to carry out the inspection to the satisfaction of the Engineer, shall be included in the rate of the items of the Bill of Quantities No. 12 - Outdoor Lighting MV/LV and Telephone Networks.

There shall be no measurement or payment for the remedial replacement and/or additional work, including additional testing and inspection work, which is a consequence of any aspect of the works failing any test or which is due to the Contractor's failure to carry out the works in accordance with the requirements of the Contract Documents.

1212.12 Photocell Switches

1212.12.1 Measurement - Photocell Switches shall be each enumerated

1212.12.2 Payment - Rate for photocell switches shall include material, supporting brackets, connections, terminations and all necessary accessories.

1212.13 Cable Junction

1212.13.1 Measurement - Cable junction shall be each enumerated in number of sets stating the specification of the cables to be connected

1212.13.2 Payment - Rate for cable junction shall include stripping, termination, connection, insulations, fillers, boxes and all necessary accessories to the satisfaction of the Engineer and to EDL requirements.

1212.14 EDL Power Supply Cost

1212.14.1 Measurement - EDL power supply cost shall be enumerated.

1212.14.2 Payment - Rate for EDL power supply cost shall include application, coordination, materials and labor cost charged by EDL (Electricité du Liban), attendance and coordination by Contractor, and for overhead and profit.

1212.15 Relocation of Telephone Poles and Cables

1212.15.1 Measurement

a. Relocation of Telephone Poles and Cables shall be enumerated.

- b. Supply and installation of new overhead telephone cables shall be measured in linear meter.

1212.15.2 Payment

a. Rate for relocation of telephone poles and cables shall include dismantling and reinstallation of telephone poles and cables along the new road edge, all related civil works (earthworks, concrete works, etc.), realignment of cables and all necessary accessories. All works shall be carried out with close coordination and under the supervision of Ministry of Telecommunication.

b. Rate for supply and installation of new overhead telephone cables shall include for supply and installation of new cables, termination boxes, cable, clamps, brackets, all as per MOT requirements.

1212.16 Relocation of Power Steel Poles and Cables

1212.16.1 Measurement

a. Dismantling and installation of Power Steel Poles and Cables shall be enumerated irrespective of the heights.

b. Dismantling and reinstallation of existing overhead low voltage cables shall be enumerated irrespective of cable sizes, numbers, and lengths per interval.

c. Dismantling of existing electric steel poles shall be enumerated irrespective of the heights.

d. Dismantling of existing lighting units and fixing arrangements shall be enumerated irrespective of the heights

e. Supply and installation of copper conduction overhead lines shall be measured in kilogramme.

f. Reparation of existing and damaged electrical poles shall be enumerated.

1212.16.2 Payment - Rate(s) of item(s) included under relocation of power steel poles, and cables shall include dismantling and/or reinstallation of overhead poles and cables along the new road edge, all related civil works (earthworks, concrete works, etc.), cables, isolators and all other accessories and materials, removal and/or transportation to authorities of all salvage material or to designated location by the Engineer. All works shall be coordinated and approved by EDL.

Rate for supply and installation of copper conduction overhead lines shall include supports, insulation, brackets, all as per EDL specifications.

1212.17 Relocation of Substation Equipment

1212.17.1 Measurement - Relocation of substation equipment shall be enumerated.

1212.17.2 Payment - Rate for relocation of substation equipment shall exclude cables since they are measured elsewhere and shall include removal, reinstallation, testing and commissioning of existing substation equipment to the new building, transformer, ringmain unit, LV switchgear, connection of LV and HV cables to equipment, complete as directed by EDL, and all necessary labour, materials, and equipment to complete the work.

1212.18 Levelling of Manholes and Handholes and Top Slabs and Necks

1212.18.1 Measurement – Levelling of manholes and handholes top slabs and necks shall be enumerated.

1212.18.2 Payment - Rate for levelling of manholes and handholes top slabs and necks shall include for removing of existing manhole and/or handhole covers and frames, maintaining the integrity of the manhole, providing protection for inside components and cleaning debris, without interruption of services, all as directed, shown on Drawings and to the satisfaction of MOT.

1212.19 Demolition of manholes and handholes

1212.19.1 Measurement - Demolition of existing manholes and handholes shall be enumerated.

1212.19.2 Payment - Payment shall be at the rates inserted in the Bill of Quantities, which rate shall be deemed to include for all labour, materials (including fuel), equipment, removal of demolished items, debris, etc. to an approved dumping site, overhead and profit, and all necessary protection works to carry out such works complete.

The Contractor's rates shall also be deemed to include for the removal for storage or re-use of all existing materials or other items so designated by the Engineer, unless such items are measured separately in the Bill of Quantities.

**** END OF SECTION ****

ANNEX 1

PROJECT SIGN BOARD



TEMPORARY SIGN BOARD
(ALL DIMENSIONS ARE IN CENTIMETERS)