

Technical Specifications

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Standard Specifications

Latest Editions of the following specifications published by British Standard Institute (BSI) shall be used in respect of this contract in addition to foregoing specifications.

1. BS 1377
2. BS 7263
3. Specifications for Irrigation and Land Drainage Works
4. Specifications for Electrical and Mechanical Works associated with Building and Civil Engineering.

Specifications in addition to the above specifications are included in the Special Provisions of the contract document. Any specifications which are not covered by the Standard Specifications and/or Special Provisions will be issued by the Engineer on request.

In case of conflicts among the specifications, more stringent version shall be applicable to the contract.

Section 01010:Summary of Works

Part 1 - General

1.01 Description of the Works

The scope of work for the project is described in the Particular Specifications.

1.02 Contract

1. The Particular Specifications and the Technical Specifications shall be read in conjunction with the other Contract Documents.
2. The Technical Specifications are to provide overall guidance in the execution of the Works and shall apply except where contradicted by the Particular Specifications.
3. Notwithstanding anything contained herein, the Contractor shall be responsible for complying in all respects with any such Bylaws and Regulations as may be in force at the time of execution of the Works.
4. The Contractor shall provide, and do everything necessary, for the proper execution of the Works according to the intent and meaning of the Tender and Contract Documents.
5. The Works shall be completed in strict accordance with the Contract Documents and with any further drawings, or instructions, issued, or approved, by the Engineer during the execution of the Works.
6. The work to be performed under this Contract includes, but is not necessarily limited to, the furnishing of all supervision, labor, materials, temporary works, false work, plant, machinery, equipment, parts, tools, supplies, transportation, utilities, construction facilities, incidentals and logistic support necessary for the performance and maintenance of the Works, accomplishing the same in a professional and workmanlike manner.
7. All work shall be executed by skilled tradesmen who shall be thoroughly acquainted with all aspects of their trade, including any special local customs and modes of operation.
8. Workmanship will be accepted of only the highest standard.
9. The Contractor shall be deemed to have based his Tender on the information in respect of hydrological, physical and climatic conditions of the site and inspected the site and its surroundings and satisfied himself of all conditions before submitting his tender.

10. The Engineer and any person authorized by him shall, at all times, have access to the Works and to the site and to all workshops, stores and places associated with the Works.

1.03 Work Performed by Others

During the construction of the Works the Contractor shall ensure that none of his activities cause undue hindrance to others in the performance of their duties.

1.04 Contractor's Use of Site

- A. Access to the site shall be maintained by the Contractor at all times and all necessary steps shall be taken to ensure the safety of persons on the Site.
- B. All construction operations and site establishment facilities shall be confined to within the Site boundaries, as shown on the Drawings, unless otherwise approved by the Engineer and the relevant authorities. Following such approvals, all such areas shall also be designated and treated as included within the definition of the word "Site".
- C. The Contractor shall be responsible for safeguarding all structures and the like in the vicinity of the Site and shall ascertain from the public utility authorities positions of all existing underground services and shall maintain and protect or divert them as required.

1.05 Occupancy

- A. The Contractor shall inspect and examine the Site and its surroundings and shall satisfy himself before submitting his Tender as to the nature of the ground and sub soil, the quantities and nature of the work and materials, tools and equipment necessary for the completion of the Works. No claim will be considered for additional expenses the Contractor may incur on account of any unforeseen obstacle of whatever nature, over and above those which would have been incurred had the existence of the obstacle been known at the Tender stage. Any excavations needed to determine the exact location, and levels of obstacles, shall be done by the Contractor. The Contractor shall obtain all further information required as to the risks, contingencies and other circumstances, which may influence or affect the execution of the Works and include the costs thereof in his Tender.
- B. The information and details of existing services given on the Drawings are not guaranteed to be accurate, or correct, and are given for guidance in compiling the Tender. The Contractor shall make his own investigations and inquiries to all service authorities to ascertain what services exist at the Site, and get details of their exact positions, sizes, numbers etc. When the Contractor intends to carry out work in the vicinity of existing services, he shall notify the owner of each particular service present, of his intent to do so, at least one month in advance of his anticipated start date. The Contractor shall prepare a Notice of Intent signed by the Engineer, the service authority concerned and the Contractor's representative. The Contractor shall uncover and verify locations of all services in accordance with any special

requirements of the services authority concerned. The Contractor shall not be allowed to work in any area where services are buried until the Contractor has uncovered and located them both vertically and horizontally. The Engineer shall have the right to stop the work in any part of the Works where the Contractor fails to take the necessary measures to uncover such services. The Employer shall not consider any claims from the Contractor resulting from such instructions. The Contractor shall refer to, and comply with, the current regulations of all the relevant service authorities before commencing any work adjacent to services. These requirements will not relieve the Contractor of any responsibility for taking every precaution to avoid damage to any service. The Contractor will be held responsible for the cost or repair of all damage.

1.06 Items Furnished by the Employer

- A. The Employer reserves the right to place and install equipment, furniture, furnishings, etc., in completed or partially completed areas of the Works upon the understanding that the exercising of such right will not substantially interfere with the regular progress and completion of the Works.
- B. The Employer reserves the right to occupy completed parts of the Works prior to substantial completion of the whole of the Works, provided that such occupancy does not substantially interfere with completion of the remaining parts of the Works.

End of Section 01010

Section 01041: Project Co-ordination

Part 1 - General

1.01 Description

The Contractor shall provide the administrative and supervisory personnel necessary for project co-ordination, construction, completion, commissioning and maintenance.

1.02 Co-ordination

- A. The Contractor shall co-ordinate construction activities, included under various sections of these Specifications, to ensure efficient and orderly delivery and installation of each part of the Works, and shall co-ordinate construction operations, included under different sections of the Specifications, that are dependent upon each other for proper installation, connection, and operation. Where installation of one part of the Works is dependent on installation of other components, either before or after its own installation, the Contractor shall schedule construction activities in the sequence required to obtain best results. Where availability of space is limited, the Contractor shall co ordinate installation of different components to ensure maximum accessibility for required maintenance, service and repair and make adequate provisions to accommodate items scheduled for later installation. The Contractor shall, where necessary, prepare details for distribution to each party involved outlining special procedures required for co-ordination including such items as required notices, reports and attendance at meetings. Similar details shall be prepared for the Employer and separate contractors where co-ordination of their work is required.
- B. The Contractor shall co-ordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and ensure orderly progress of the work. Such administrative activities shall include, but are not limited to, the following:
 - a. preparation of schedules,
 - b. installation and removal of temporary facilities,
 - c. delivery and processing of submittals,
 - d. progress meetings,
 - e. project close-out activities.
- C. The Contractor shall prepare, and submit, co-ordination drawings where careful co-ordination is required for installation of products; where materials are fabricated off-site by separate entities and where limited access availability necessitates maximum utilization of space for efficient installation of different components. These drawings shall indicate the interrelationship of components detailed on separate shop drawings, required installation sequences and shall comply with requirements contained in Section 01300. The Contractor shall take special care and precautions for specific co ordination requirements for plant, equipment and other electromechanical installations, specified elsewhere or otherwise required.
- D. The arrangement of the Specifications into divisions, sections, clauses, sub clauses and paragraphs, shall not control the division of work among sub-contractors, nor establish

the extent of work to be performed by any particular trade or sub-contractor. The Contractor shall be responsible for the proper co-ordination of all Works including that required between different trades and different sub-contractors, suppliers, utility agencies, governmental authorities, etc.

End of Section 01041

Section 01043: Job Site Administration

Part 1 General

1.01 Description

This Section includes requirements for Contractor's supervisory staff and administration procedures.

1.02 Details of Contractor's Supervisory Staff and Subcontractors

The Contractor shall provide the names and details of the experience, qualifications, language capabilities and previous appointments for the supervisory staff, including those of the sub-contractors, who will be allocated to the project. These details shall be for the same personnel and sub-contractors as detailed in the Contractor's tender. If alternative personnel or sub-contractors are proposed, then the Contractor shall provide a detailed comparison of original and substitute personnel and sub-contractors. Approval of alternative personnel or sub-contractors will not be given readily.

It shall be clearly understood that the supervisory staff and sub-contractors, as detailed in the tender, shall be made available for the execution of the work under this Contract. The provision of the supervisory staff and sub-contractors, proposed by the Contractor in the tender, does not relieve him, in any way, of his liability under the Contract to provide all the staff necessary for the satisfactory completion, commissioning and maintenance of works and within the dates stated in the Contract. Each person and sub-contractor listed in the tender is subject to final approval by the Engineer. Approval of the Contractor's supervisory staff and sub-contractors does not waive the right of the Engineer to withdraw that approval at any time thereafter, as provided for in the Contract.

1.03 Use of Site

The Site shall not be used for any purpose other than the work of this Contract.

1.04 Advertising

Advertisements shall not be displayed or permitted on, or along, the Site without consent of the Engineer.

1.05 Working Hours

The normal working hours of the Engineer and his Representative's supervisory staff are fixed by the Employer and shall be in accordance with local laws. The Engineer shall approve the starting and finishing times of the Contractor's working day and week.

1.06 Accident Prevention

Refer to Section 01500.

1.07 Adjoining Plant and Property

The Contractor shall take all reasonable precautions to avoid interference with the operation of, and to prevent damage to, adjoining plant and property. To use adjoining property the Contractor shall obtain all permissions, as necessary, from the Municipality and other relevant agencies, and the Contractor shall pay all charges, as required. All areas affected by the Works shall be cleared of excess material, trash and repairs made to the satisfaction of the property owner, Municipality, relevant agencies and the Engineer.

1.08 Temporary Work

The Contractor shall provide, and maintain during the execution of the Works, all shoring, bracing and other supports, safety devices, lighting, barricades and other temporary items as may be necessary to preserve the stability of all plant and property that may be endangered, or affected, by the Works.

1.09 Roads and Footpaths

The Contractor shall ensure that no damage, beyond normal wear and tear, is caused by delivery or construction traffic to roads and footpaths outside the site boundaries. Approaches to the site shall be adequately maintained. The Contractor will be required to repair damage directly attributable to his work.

1.10 Labour Record

Daily records shall be submitted to the Engineer in a format to be approved by the Engineer, showing the number and description of craftsmen, laborers and other persons employed on or in connection with the Works, including those employed by sub contractors. This record shall be incorporated in the Daily Construction Report (see Section 01300).

1.11 Plant Record

A daily plant record shall be submitted to the Engineer in a format to be approved by the Engineer, showing the type, model and capacity, whether working, idle or under maintenance, of all mechanical and power operated plant employed on the Works. The Contractor will not be permitted to remove any plant unless written approval is obtained from the Engineer. This record shall be incorporated in the Daily Construction Report (see Section 01300).

1.12 Overtime Working

Whenever working outside normal hours is proposed, the Contractor shall request approval from the Engineer giving not less than one working day notice, specifying times, types and locations of work and approximate number of labour, supervisors and plant involved. Concealed work executed outside normal hours for which approval has not been given may be required to be opened up for inspection and/or reinstated at the Contractor's expense.

1.13 Defective Works

When any part of the Work is known or suspected to be defective, the Contractor shall submit proposals, as soon as possible, to the Engineer, for his approval, for further testing, opening up,

inspection, making good or removal and re execution. Whenever inspection or testing shows that any part of the Works is not in accordance with the Contract, and measures are taken to establish the acceptability of the work (eg further testing, opening up, experimental making good), such measures will be at the expense of the Contractor, and not considered as grounds for extension of time.

End of Section 01043

Section 01050: Field Engineering

Part 1 General

1.01 Description

This Section includes the Contractor's responsibility for correctness of measurements.

1.02 Grades, Lines and Levels

- A. The Contractor shall verify all measurements and be responsible for their correctness. Any differences which may be found between actual measurements and the dimensions given in the Contract Documents shall be submitted to the Engineer, in writing, for consideration and directives before proceeding with the Works.
- B. Site bench marks shall be accurately and safely established, maintained and removed upon completion of the Works, all to the satisfaction of the Engineer. The Engineer will indicate the position, co-ordinates and elevation of bench marks near the works, as shown on the Drawings.
- C. The Contractor shall prepare a plan detailing the location of the bench marks and keep this up-to-date throughout the period of the Contract. Reproducible copies of the plan so prepared shall be supplied to the Engineer, as and when he may require.
- D. The Engineer reserves the right to order levels, considered necessary for the full and proper supervision and measurement of the works, to be taken at any time.
- E. Before the Works, or any part thereof, are commenced, the Contractor and the Engineer shall together make a complete survey, and take levels, of the Site and agree on the dimensions and elevations upon which setting out of the Works shall be based.
- F. These levels shall be related to the bench marks and shall be plotted and drawn up by the Contractor. After agreement of the drawings, which shall be signed by the Engineer and the Contractor, these levels shall form the basis of setting out of the Works.
- G. Failing such surveys and agreements being prepared and/or signed by the Contractor, the surveys of the Engineer shall be final and binding upon both parties.
- H. The Contractor shall submit the original of the drawings, and three copies, to the Engineer.

1.03 Setting Out

- A. The Contractor shall be responsible for the true and proper setting out of the Works in relation to reference data given on the Drawings and shall accurately set out the positions, levels and dimensions of all parts of the Works. Any delay or loss resulting from errors in the setting out of the Works shall be the responsibility of the Contractor.

- B. Setting out shall be reviewed by the Engineer before commencing the Works, but any approval shall, in no way, relieve the Contractor of his responsibility for the correct execution of the Work.
- C. Setting out of the Works shall use methods and the necessary instruments described in BS 5606 "Code of Practice for Accuracy in Building". The Contractor shall maintain, in good working order at all times, the instruments provided by him for the setting out of the Works and shall make such instruments available to the Engineer as instructed for checking or taking measurements.
- D. The Contractor shall provide all assistance which the Engineer may require for taking measurements of the Works, including labour, equipment and transportation.

1.04 Non Compliance

Work, which fails to meet the specified levels of accuracy, shall be rectified but not without approval. Proposed rectification measures shall be submitted to the Engineer for approval. The Contractor shall note that rectification measures may include removal and replacement of sub-standard work at no cost to the Employer. All costs and losses associated with rectification of sub-standard work shall be borne by the Contractor.

End of Section 01050

Section 01090: References and Standards

Part 1 General

1.01 Description

The Contractor shall comply with all codes, standards, specifications of regulatory agencies, specifications and standards referred to throughout the contract documents.

1.02 Definitions

- A. Where "as shown", "as indicated", "as detailed", or words of similar import are used, it shall be understood that reference to the Drawings and Specifications is made unless otherwise stated.
- B. Where "as approved", "as reviewed", "as accepted", or words of similar import are used, it shall be understood that the approval, direction, requirement, permission, authorization, review, or acceptance of the Engineer is intended, unless otherwise stated.
- C. As used in the Contract, "provide" shall be understood to mean "provide complete in place", that is, "furnish and install".

1.03 Reference Standards

- D. All references to codes, local and administrative orders, regulatory agency requirements, specifications and standards referred to in the Contract Documents shall, unless otherwise stated, mean the latest edition, amendment or revision of such reference standards in effect at the date of submission of the tender.
- E. The Contractor shall obtain an original copy of the latest edition of all standards, codes, local and administrative orders, regulations, standards and technical literature referred to in the Contract Documents and the same shall be properly indexed and handed to the Engineer within 42 days of the Letter of Acceptance of the Works. Upon completion of the works the said codes, standards, etc. shall become the property of the Employer.
- F. Whenever the Contract Documents require that a product complies with Japanese Standards, British Standard, ASTM Designation, ANSI Specification Federal Specification or other association standard, etc., the Contractor shall present an affidavit from the manufacturer certifying that the product complies therewith. Where requested, or specified, the Contractor shall submit supporting test data to substantiate compliance.
- G. Materials which meet standards equivalent to Japanese (JIS), American (ANSI), British (BS), German (DIN) standards or other internationally recognized standards shall be acceptable, provided that the Contractor substantiates their equivalence and ensures their compatibility with other components of the system. Copies of the current version of the proposed standards, and a comparison with any specified standard, shall be submitted to the Engineer. The proposed details which qualify such items as being of

the acceptable quality shall be submitted to the Engineer for approval in accordance with Section 1300.

- H. Where a reference standard referred to herein is in the form of a recommendation or suggestion, such recommendation or suggestion shall be deemed to be mandatory under this Contract unless conflicting with particular specifications contained herein.
- I. There may be items for which there are no relative codes, specifications or standards, and materials and workmanship of such items shall be of suitable quality and conform to Japanese, Western European or USA industry norms.

1.04 Abbreviations and Standards

- A. The following abbreviations are used in the Specifications:

d	Day
dia	Diameter
ha	Hectare
h	Hour
hwl	high water level
kg	Kilogram
km	Kilometre
kN	kilo Newton
kW	Kilowatt
l	Litre
lwl	low water level
m	Metre
m ² , sq	msquare metre
m ³ , cu	mcubic metre
MDD	maximum dry density
mg	Milligram
mm	Millimetre
Mg	megagram (1000 kg)
MPa	mega Pascal
nr	Number
s	Second

- B. Reference to a technical society, institution, association or governmental authority is made in the Specifications in accordance with the following abbreviations:

AA	Aluminium Association
AABC	Associated Air Balance Council
AAN	American Association of Nurserymen
AAMA	Architectural Aluminium Manufacturers Association
AASHTO	American Assoc. of State Highway and Transportation Officials
ACI	American Concrete Institute
ADC	Air Diffuser Council
AFI	Air Filter Institute
AGCA	Association of General Contractors of America

AGMA	American Gear Manufacturers Association of America
AIA	American Institute of Architects
AIMA	Acoustical & Insulating Materials Association.
AIEE	American Institute of Electrical Engineering
AISC	American Institute of Steel Construction
AISI	American Iron & Steel Institute
AITC	American Institute of Timber Construction
ALS	American Lumber Standards
AMCA	Air Moving & Conditioning Association
ANSI	American National Standards Institute
AOAC	Association of Official Agricultural Chemists
APA	American Plywood Association
ARI	Air Conditioning & Refrigeration Institute
ASAH	American Society of Architectural Hardware Engineers
ASHRAE	American Soc. of Heating, Refrigerating and Air-con. Engineers
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing & Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute
AWS	American Welding Society
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers Ass.
BIA	Brick Institute of America
BRI	Building Research Institute
BS	British Standard
BSCP	British Standard Code of Practice
BSI	British Standards Institution
CDA	Copper Development Association
CEE	Int'l. Commission on Rules for Approval of Electrical Equipment
CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standard, U.S. Department of Commerce
CSI	Construction Specifications Institute
CTI	Cooling Tower Institute
DIN	Deutsche Institute fur Normung, Germany
FGMA	Flat Glass Marketing Association
FPL	Forest Products Laboratory
FS	Federal Specification
FSIWA	Federation of Sewage & Industrial Waste Association
FTI	Facing Tile Institute
GA	Gypsum Association
GTA	Glass Tempering Association
HPMA	Hardwood Plywood Manufacturers Association
IEC	Int'l. Electrotechnical Commission
IEE	Institute of Electrical Engineers, London
IEEE	Institute of Electrical & Electronics Engineering
IES	Illuminating Engineering Society
ISO	International Organization for Standardization, Switzerland

JIS	Japanese Industrial Standards
MIA	Marble Institute of America
MLMA	Metal Lath Manufacturers Association
MSSVFI	Manufacturer's Standardization Society of the Valves and Fittings Industries
NAAMM	National Association of Architectural Metal Manufacturers
NAFM	National Association of Fan Manufacturers
NAPM	National Association of Plastic Manufacturers
NBGQA	National Building Granite Quarries Association
NBHA	National Builders Hardware Association
NBS	National Bureau of Standards
NCMA	National Concrete Masonry Association
NEC	National Electrical Code (NFPA No.70)
NEMA	National Electrical Manufacturers Association
NEMI	National Elevator Mfg. Industry, Inc.
NFC	National Fire Code
NFPA	National Fire Protection Association
NFPA	National Forest Products Association
NHLA	National Hardwood Lumber Association
NHPMA	National Hardwood & Pine Manufactures Association
NPA	National Particleboard Association
NRMCA	National Ready Mixed Concrete Association
NSC	National Safety Council
NSF	National Sanitation Foundation
NTMA	National Terrazzo & Mosaic Association
NWC	National Water Council, UK
NWMA	National Woodwork Manufacturers Association
OSHA	Occupational Safety & Health Administration
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDI	Plumbing & Drainage Institute, USA
PEI	Porcelain Enamel Institute
PS	Product Standard, U.S. Dept. of Commerce
RIS	Redwood Inspection Service
RTI	Resilient Tile Institute
SCMA	Southern Cypress Manufacturers Association
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association.
SJI	Steel Joint Institute
SMACNA	Sheet Metal & Air Conditioning Contractors National Association
SMFMA	Sprayed Mineral Fiber Manufacturers Association, Inc.
SPIB	Southern Pine Inspection Bureau
SPR	Simplified Practice Recommendation, U.S. Dept. of Commerce
SSPC	Steel Structure Painting council
SWFPA	Structural Wood Fiber Products Association
TCA	Tile Council of America
TEMA	Tubular Exchange Manufacturing Association
TIMA	Thermal Insulation Manufacturers Association
TPI	Truss Plate Institute

UL	Underwriters Laboratories, Inc.
UPC	Uniform Plumbing Code
USCGS	U.S. Coast & Geodetic Survey
WCLB	West Coast Lumber Inspection Bureau
WRI	Wire Reinforcement Institute
WPA	Western Wood Products Association

End of Section 01090

Section 01200: Meetings

Part 1 General

1.01 Description

This Section includes:

1. Pre-Construction Conferences
2. Progress Meetings
3. Subcontractor's Site Meetings
4. Pre-Installation Conference
5. Pre-Startup Conference
6. Pre-Training Conference
7. Post-Construction Conference
8. Minutes of Meetings

1.02 Pre-construction Conference

- A. A pre-construction conference shall be held at the project site, or other approved location, within 28 days after the date of the Letter of Acceptance and shall be attended by the Employer, the Engineer, the Engineer's Representative and Contractor.
- B. The agenda shall be provided by the Engineer's representative a minimum of three working days prior to the conference. Topics of discussion shall include, but not necessarily be limited to, the following:
 1. Contractor's organization for the project, including names, titles and language capabilities of all persons authorized by the Contractor to represent and execute documents for him, with samples of all authorized signatures, and also names, addresses, and telephone numbers of all those authorized by the Contractor to act for him in emergencies,
 2. communication channels and procedures,
 3. project meeting schedule,
 4. construction schedule including the sequence of critical work,
 5. a financial estimate of the amount of work to be performed each month by the Contractor,
 6. contract documents including distribution of required copies,
 7. submittal processing including forms and procedures,
 8. payment application forms and procedures and the revised progress schedule reports to accompany the applications,
 9. field order and variation order processing,
 10. rules and regulations governing performance of the Work including:
 - a. construction permit requirements, procedures, and posting,
 - b. procedures concerning the installation of Work on public or private property not owned by the Employer,
 - c. access and rights-of-way furnished by the Employer,.
 - d. Contractor's provisions for barricades, traffic control, utilities, sanitary facilities and other temporary facilities and controls,
 - e. inspector and his duties,
 - f. construction surveyor and initiation of surveying services,
 - g. testing laboratory or agency and testing procedures,

- h. public notice of starting work,
- 11. project sign board,
- 12. safety and first aid,
- 13. site security,
- 14. quality control,
- 15. construction equipment and methods proposed by the Contractor,
- 16. procedures for plant and labor returns by the Contractor,
- 17. miscellaneous project requirements such as housekeeping etc,
- 18. monitoring and reporting procedures for work progress, project costs, materials, labor and equipment procurement, etc.,
- 19. Contractor mobilization and use of the project site,
- 20. other administrative and general matters as needed.

1.03 Progress Meetings

- A. Progress meetings shall be held twice each month to review work progress and performance as well as to review the Contractor's 90-day, look-ahead schedule. Progress and schedule reviews shall verify:
 - 1. actual start and finish dates for activities completed during the update period,
 - 2. remaining duration and percentage of completion for all activities not completed,
 - 3. logic, activity duration, and cost data for variation order work that will be incorporated into the construction schedule,
 - 4. Contractor's proposed measures to recover any lost time and place the project back on schedule; such as increasing manpower, materials and equipment resources and working extended hours, or additional shifts,
 - 5. sub-contractor activity,
 - 6. other items not listed above including, without limitation, any unresolved matters, deficiencies in the work or methods employed for the work, and problems, difficulties, or delays which have been, or maybe encountered.
- B. Meetings shall be attended by the Employer, the Engineer, the Engineer's Representative, the Contractor and his Site Agent. Subcontractors may attend when involved in the matters to be discussed, or resolved, but only when requested by the Employer or the Engineer. In addition to the attendees named herewith, the meeting shall be attended by the representatives of regulatory agencies having jurisdiction over the Project, if required, and such other persons the Employer may designate.
- C. The time and location of the progress meetings shall be as directed by the Engineer's Representative who shall chair the meetings.
- D. The Contractor shall submit the information itemized below to the Engineer at least three working days prior to each progress meeting:
 - 1. a list of completed activities,
 - 2. a list of current activities with an estimate of time required for completion,
 - 3. a list of changes to planned starting dates and durations for all outstanding activities,
 - 4. percentage of completion for each current activity,
 - 5. a list of activities planned to start in the next period,
 - 6. other information required by the Engineer's Representative.

- E. A request for additional meetings required by the Contractor shall be submitted to the Engineer's Representative, in writing, providing a proposed agenda for the meeting and the names of all personnel who are required to attend. The Engineer's Representative shall chair these meetings.

1.04 Sub-contractor's Site Meetings

The Contractor shall meet with subcontractors and suppliers prior to each progress meeting. The agenda should be identical to that presented above for the Contractor's progress meetings.

1.05 Pre-installation Conference

- A. When required by specification sections, the Contractor shall meet with subcontractors, equipment manufacturers and the Engineer to review equipment installation requirements.
- B. Attendance shall be by personnel performing the work, personnel who may be affected by the work, and by the equipment manufacturer.
- C. Site conditions, preparation requirements, logistics and installation procedures shall be reviewed.

1.06 Pre-startup Conference

- A. A pre-startup meeting shall be required prior to starting up any component, sub-system, or system and shall comply with requirements specified in Section 01650.
- B. The Contractor, mechanical coordinator, commissioning engineers, start-up foreman, Engineer and his representatives, plant operations staff, and equipment manufacturers (if necessary) shall attend.
- C. The agenda shall be provided by the Engineer's Representative a minimum of three working days prior to the conference. Topics of discussion will include but not necessarily be limited to the following:
 - 1. start-up and validation prerequisites,
 - 2. start-up plan and schedule,
 - 3. temporary connections,
 - 4. spare parts, chemicals, and operating fluids,
 - 5. coordination with plant operating staff to minimize disruption to any existing plant operation,
 - 6. other items deemed necessary by the Engineer's Representative.

1.07 Post-construction Conference

- A. The conference shall be held prior to final inspection of the Work. The Employer, Engineer, Engineer's Representatives, Contractor and his supervisory staff shall attend.

- B. The agenda shall be provided by the Engineer's Representatives a minimum of three working days prior to the conference. Topics of discussion will include but not necessarily be limited to the following:
1. discuss and resolve all unsettled matters,
 2. guarantees and insurances,
 3. schedules and procedures for the final inspection process,
 4. correction of defects and deficiencies,
 5. documents required to be submitted by the Contractor,
 6. other items deemed necessary by the Engineer.

1.08 Minutes of Meetings

The Engineer's Representative will record minutes of each meeting and a copy of the minutes shall be furnished to the Contractor within five working days. The Contractor shall submit written objections, if any, to the contents of minutes within three days after presentation to him. In the absence of any objection, it shall be understood and agreed that the Contractor accepts the minutes as a true and complete record of the meeting.

End of Section 01200

Section 01300: Submittals

Part 1 General

1.01 Description

This Section includes:

1. Definitions
2. Submittal Procedures
3. Product Data
4. Drawings
5. Samples
6. Operation and Maintenance Manuals
7. Certificates and Affidavits
8. Miscellaneous Submissions

1.02 Definitions

- A. The Contract drawings are diagrammatic and show the general layout of the complete construction work. The Contractor shall review the Drawings and Specifications and shall include work shown thereon required for the installations. The Contractor shall be responsible for preparing, and submitting to the Engineer for review, all general arrangement drawings showing the inter-relationships between civil construction and all mechanical, electrical and instrumentation equipment to be installed, if any. Should there be a need to deviate from the Contract drawings and Specifications, the Contractor shall submit written details and reasons for all changes to the Engineer for approval before making such changes. All extra costs to make the changes will be borne by the Contractor. In the event of varying interpretations of the Contract Documents, the Engineer's interpretation shall govern.
- B. Product data and shop drawings include drawings, diagrams, illustrations, brochures, schedules, bills of materials, and other data prepared specifically for the Work. Information may be prepared by Contractor, his sub-contractors, suppliers or distributors, equipment manufacturer, or fabricators. Information must illustrate or describe manufacture, fabrication, construction, and installation of the Work or a portion thereof.
- C. The manufacturer's representative is a person actively working at manufacturer's factory with minimum five years experience and who is familiar with problems of manufacturing, installing, and operating the product. Sales representatives or agents shall not be considered as manufacturer's representatives.
- D. Working drawings are the Contractor-prepared plans for temporary structures and facilities. Elements of Work, which may affect the safety of persons, or property, shall be certified by a qualified engineer. Calculations demonstrating adequacy of the Contractor's design shall be submitted with any working drawings.
- E. Samples are physical examples illustrating materials, equipment, or workmanship to establish standards by which the Work will be judged.

- F. Manuals are the manufacturer's written installation, start-up, operating, maintenance and repair instructions including parts lists, pictures, sketches and diagrams specific to the equipment supplied to document the manufacturer's requirements and instructions.
- G. The format of drawings shall conform to:
 - 1. drawings shall be in A-sized format and no larger than A-1 size,
 - 2. scales shall be standard scales of 1:1, 1:2, 1:5 and multiples of ten thereof. Plans and pipeline profiles may be to scales of 1:1250 and 1:2500. No other scales shall be used,
 - 3. all other documentation shall be A-4 size

1.03 Submittal Procedures

- A. Only the Contractor shall make submissions to the Engineer. All data and correspondence prepared by sub-contractors and suppliers shall be submitted through the Contractor. All submittals shall be in English. The Contractor shall prepare submittals with sufficient information, and in such a manner, that no more than two resubmittals are necessary to obtain the Engineer's approval. If more than two resubmittals are required, the Employer reserves the right to deduct the cost of the Engineer's time to review all additional resubmittals (after re-submittal no. 2) from moneys due to the Contractor.
- B. The Contractor shall review and approve all drawings, product data, samples and manuals required to be submitted as by the Contract Documents. Review and approval shall be for compliance with the contract requirements. Approval by the Contractor indicates that the Contractor has verified all materials, field measurements, field construction criteria and similar items. Approval also indicates that the Contractor has coordinated information contained in the submittal with Work requirements of other trades and with the Contract Documents. The Contractor review and submission to the Engineer shall be timely so as to not delay the work.
- C. The Contractor shall make all corrections and changes to submittals as required by the Engineer and resubmit until approved. The Contractor shall review submittals returned by the Engineer and shall determine if changes requested by the Engineer result in extra cost. The Contractor shall notify the Engineer in writing within five days of receiving a submittal if the Contractor believes extra costs are incurred and indicate on his submittals to the Engineer. Failure of the Contractor to notify the Engineer of the extra costs, or if the Contractor proceeds with the work, waives the Contractor claim for compensation.
- D. Submissions of manufacturer's data, including data specified as "for information only", shall be made prior to beginning any portion of the work using materials or equipment contained in the submittal.
- E. The Contractor shall submit drawings and product data in accordance with the approved schedule and shall allow sufficient time for the Engineer's review, approval, and transmittal back to the Contractor.

- F. The Contractor shall detail items not completely described on the Contract Drawings in accordance with standard engineering practice and shall adjust dimensions of concrete and building structures shown on the Contract Drawings to reflect actual dimensions of equipment to be provided. The Contractor shall coordinate dimensions shown on the Drawings as well as actual equipment dimensions with measurements of existing, adjacent, incorporated, and completed work to ensure all components fit into the space available and shall verify all dimensions before beginning any work depending on such data.
- G. The Contractor shall identify each and every deviation from the Contract Documents to the Engineer, either on the drawing, or in the letter of transmittal. Reasons for the deviation shall be explained and the requested deviation compared with contract requirement and an explanation given as to why the deviation is equal to or better than contract requirement. The Contractor will not be relieved of responsibility for executing work in complete conformance with the Contract for submittals not identifying deviations, even though such submittals have been approved.
- H. The Contractor shall submit drawings and product data for related equipment items and integrated system components at the same time. Partial submissions may be returned to the Contractor without review.
1. The Contractor shall coordinate drawings and product data, and such coordination shall include:
 2. drawings and data previously submitted,
 3. drawings and data being prepared
 4. drawings and data previously approved.

The Contractor's approval and submission of drawings and data to the Engineer indicates that such coordination has been performed and completed.

- I. The Contractor shall direct the Engineer's attention, either in writing or on the re-submitted documents, to each and every revision other than those requested by the Engineer on previous submittals.
- J. Materials or equipment shall not be delivered, either to storage or to the project site, and shall not be incorporated into the work, until it has been approved, or authorized, in writing, by the Engineer.
- K. The Contractor shall not perform any work until drawings or data have been submitted to, and approved by, the Engineer.
- L. All submittals from the Contractor shall include a label or stamp completed by the Contractor and which indicates that the submittal has been reviewed and approved by the Contractor for conformance to the contract requirements. The labels or stamp shall generally conform to the following:

SUBMITTAL NO. _____
CONTRACT NO. _____
CONTRACTOR: _____
REVIEWED AND APPROVED (for Conformance with the Contract Documents)

BY: _____ _____ (Signature)	DATE: _____
REFERENCES: DRAWING NOS. _____ SPECIFICATION NOS. _____	

A ten character submittal identification and numbering system shall be used as follows:

1. the first character shall be, either "D", "S", "M" or "O" representing general arrangement, shop or working drawing (D), sample (S), catalogue, brochure or manual (M) and other (O),
2. the next five digits shall be the applicable specification Section number,
3. the next three digits shall be the numbers 001 through 999 to sequentially number each separate package submitted under each specific Section number,
4. the last character shall be the letter "A" through "Z" indicating whether the submittal is the first submission (A) or a re-submission (B through Z). The letter "B" indicates the second submission, "C" the third submission, etc.,
5. an example of a submittal number is D-03300-008-B, which indicates:
 - Shop Drawing
 - 03300 - Specification for Concrete
 - 008 - The eighth separate submittal under this section.
 - The second submission of that particular information.

M. Reviewed submittals will be returned to the Contractor with the Engineer's comments, if any. The Engineer's review is for general conformance with the contract requirements only and all work is still subject to the detailed requirements of the Contract. The Engineer's review is to help the Contractor to discover errors and omissions. The Engineer's review does not relieve the Contractor of the obligation and responsibility to coordinate and plan the details of the Work and fulfill the intent and purpose of the Contract. The Engineer's review shall not relieve the Contractor of the responsibility for accuracy, proper fit, or proper functioning and performance of the work. The Engineer reserves the right to require written confirmation from the Contractor that the comments placed on submittals stamped "Approved As Noted" will actually be implemented. The Engineer will make every reasonable effort to process and return each submittal within 30 calendar days after its receipt in the Engineer's office, but with the following qualifications:

1. large or multiple submittals may require additional time,
2. the Contractor may prioritize submittals and Engineer will review and return them in the order of the highest priority,
3. if requested by the Contractor, individual drawings from large submittals with numerous drawings may be returned as they are reviewed rather than waiting for the entire review to be completed,
4. the need for re-submissions or delays in obtaining the Engineer's review or approval shall not entitle the Contractor to a time extension for contract completion.

N. The categories used by the Engineer to evaluate submittals are defined below:

1. "Approved": no discrepancies have been identified,

2. "Approved As Noted": the submittal is acceptable subject to incorporation of the comments listed,
 3. "Disapproved": the submittal is unacceptable for the reasons cited,
 4. "Noted": the submittal is not required by the contract documents or the Engineer will include it in the project files for information only.
- O. Incomplete submittals including those not correctly transmitted, incorrectly titled and identified, or not bearing the Contractor's review and approval stamp may be returned to the contractor without review.
- P. Two reproducible copies, plus two photocopies or blue line prints, for each drawing are required, together with four copies of all product data and manuals. The Engineer will return one reproducible and one copy, or print, of each drawing and two copies of product data or manuals to the Contractor. The Engineer may require additional copies of all submittals by notifying the Contractor in writing and such additional copies will be at no extra cost.

1.04 Product Data

- A. The Contractor shall provide sufficient information to the Engineer to determine that the products submitted conform to the specification requirements. The data shall be explicit with regard to details of the actual products being furnished. The name of the product manufacturer shall be included on all catalogue data
- B. Submittals with more than one style, size, capacity, etc. of a product on a page shall clearly indicate which product type is being submitted for approval. Failure to do this shall be cause for disapproval.

1.05 Drawings

- A. The Contractor shall provide detailed shop drawings and written descriptions of all components and their assembly.
- B. Drawings shall indicate proposed installation of Work as well as materials and equipment being furnished.
- C. The Contractor shall identify proposed deviations from the details or component arrangement as specified or shown on the Drawings and present reasons for the proposed deviations and shall explain why proposed deviation is "equal to" or "better than" that specified.
- D. Information shown on shop drawings shall be complete and sufficient for the Engineer to review for compliance with contract requirements and to illustrate construction or assembly of the components and materials. Information shall include but not necessarily be limited to the following:
1. manufacturer, model and type,
 2. layout dimensions and component sizes including bases, foundations, anchors, and similar items,
 3. design criteria,
 4. materials of construction,

5. component and assembly weights,
 6. utility requirements (power, water, etc.),
 7. manufacturer's rating or performance curves,
 8. electrical wiring diagrams and control schematics,
 9. design computations for bearing life and AGMA rating for each driven component as appropriate,
 10. motor data,
 11. recommended spare parts,
 12. special tools,
 13. deviations from contract requirements,
 14. additional requirements contained in individual specification sections.
- E. Copies of the Contract Drawings are not acceptable for submission as general arrangement (layout) drawings.
- F. Manufacturer's model numbers or catalogue numbers alone shall not be acceptable for describing equipment or components.

1.06 Samples

- A. The Contractor shall furnish samples as required by the individual specification section. Unless otherwise specified, samples shall be submitted to Engineer as specified and labelled and properly identified with:
1. date,
 2. project / work area for which offered,
 3. specification section and applicable paragraph numbers,
 4. Contractor,
 5. supplier / manufacturer,
 6. product identification (trade name).
- B. Samples shall be accompanied by an approved transmittal form, specifications and other pertinent data required for Engineer to determine that the material conforms to the specification.
- C. Three sets of samples shall be submitted unless otherwise specified. One set of approved samples, and all disapproved samples, will be returned to the Contractor and, if requested in writing by the Contractor, samples of value will be returned to the Contractor after completion of the Work. Approved samples returned to the Contractor may only be incorporated into the work upon written approval of the Engineer.

1.07 Certificates and Affidavits

- D. The Contractor shall provide the original and seven copies of manufacturer's certificates in accordance with the requirements specified in Section 01400. A certificate indicates test results, component manufacture, or that the installation complies with specified standards. An affidavit is a sworn statement by an officer of the company manufacturing the product indicating that the information on the certificate is true and accurate. An affidavit shall accompany all certificates.

- E. A statement from the Contractor, sub-contractor, equipment supplier, or agent indicating the product meets the requirements of the Contract Documents shall not be considered a certificate and such submittals shall not be approved. Corresponding equipment, products, or components shall not be accepted.

1.08 Miscellaneous Submissions

- A. Manufacturer's guarantees and warranties shall be submitted in three copies unless otherwise specified and shall be submitted prior to final acceptance.
- B. Work plans shall be submitted in three copies, unless otherwise specified, at least 30 days prior to beginning work.
- C. The construction schedule shall show the proposed date the contractor will deliver required submittals to the Engineer for review.
- D. Accident reports shall be submitted in three copies unless otherwise specified and shall conform to Section 01400.
- E. The Contractor shall prepare and submit the Progress Reports described hereinafter in a form provided by the Engineer. Work activities and procurement reports should be referenced where relevant to the approved Contractor's Construction Schedule. The Contractor shall submit three copies unless otherwise specified. Reports shall comprise:
 - 1. Daily Reports
 - a. submit on a daily basis.
 - b. describe labor force and its allocation.
 - c. describe material and equipment utilized.
 - d. describe work progress during the day.
 - e. describe temperature and weather conditions.
 - f. describe any occurrence which may affect the progress of the Works.
 - 2. Procurement Status Reports.
 - a. submit on a weekly basis.
 - b. include a list of materials and items to be imported into the country.
 - c. include list of items delivered to the site.
 - d. provide references to all correspondence and transmittals between the Contractor and the Engineer regarding approval of such materials and items.
 - 3. Monthly Report
 - a. reflect monthly progress and status of the Work.
 - b. describe problem areas.
 - c. describe current or anticipated causes of delay along with their estimated impact on progress and the corrective measures taken or proposed.
 - d. include construction photographs.
- F. Inspection and test reports shall be submitted in three copies unless otherwise specified.
- G. Survey data shall be submitted in three copies unless otherwise specified. Survey data is required to develop quantitative record of actual work constructed, as part of damage and settlement surveys, surveys of adjacent construction and similar efforts.

H. Close-out submittals shall be as specified in Section 01700.

I. Record (as-built) documents shall be submitted in three sets unless otherwise specified.

J. Organization Chart

1. The Contractor shall submit an organization chart for the Engineer's approval not later than 28 days from the Letter of Acceptance of the Works, or prior to beginning construction activity on the site, whichever is earlier. It shall show the executive, administrative, and construction supervision organization and shall
 - a. include all personnel from Project Manager through foreman level.
 - b. describe personnel duties.
 - c. amplify details provided in the "Schedule of Data" submitted with the Tender.
 - d. provide qualifications and experience of all personnel shown on the organization chart.
 - e. indicate English language capability.
2. The Contractor shall update the organization chart whenever key personnel are reassigned.
3. The Engineer may interview any of the Contractor's proposed staff prior to approval.
4. The Engineer may direct the Contractor to remove personnel from the site who, in the engineer's sole opinion
 - a. exhibit inappropriate conduct,
 - b. who are incompetent, negligent in the performance of their duties,
 - c. for foremen and higher, if their English language capability is not satisfactory, or
 - d. who are otherwise considered undesirable.

K. The Contractor shall submit a letter of authority within fourteen days from the Letter of Acceptance of the Works, or prior to beginning construction activity on the site, whichever is earlier. It shall identify the project manager and detail the extent of his authority and responsibility. All work shall be under the direct supervision of the Contractor's on-site representative who shall be the project manager and shall be present at the job site whenever Work is underway and shall have full authority to represent the Contractor. Communication given to or received from the project manager shall be as binding as that given to or received from the Contractor.

L. The Contractor shall submit the site layout for the Contractor's facilities within twenty eight days of the Letter of Acceptance of the Works, for approval by the Engineer. The site plan should include but not necessarily be limited to the following:

1. temporary facilities including offices;
2. storage areas;
3. crane positioning;
4. fences, gates and security lighting;

5. access for other Contractors, vendors, plant staff, visitors, etc.
- M. The Contractor shall provide one original and three photocopies of transmittals and letters including attachments and enclosures. The following shall be clearly indicated on each document.
1. Contract Number.
 2. Title of Project.
 3. Contractor's Name.
 4. Date.
 5. Correspondence Reference Number.

End of Section 01300

Section 01310: Progress Schedules

Part 1 General

1.01 Description

This Section includes:

1. Interim Schedule.
2. Construction Schedule.
3. Updates and Revisions.
4. Payment Applications.
5. Requested Time Adjustment Schedule.
6. Schedule of Off-Site Activities.
7. Coordination.

1.02 General Scheduling Requirements

- A. The required completion date for this project must be met and is indicated in the Agreement and failure to meet this completion date shall result in liquidated damages being levied.
- B. The Contractor shall schedule all project activities using critical path scheduling techniques and shall update the schedule as specified. The schedule and all reports shall be computer generated. Scheduling software, which shall be Primavera, MS Project or similar, shall be approved by the Engineer. The Contractor shall use a network analysis system in either an activity on arrow or activity on node format and shall show:
 1. how the Work will be planned, executed and coordinated,
 2. the base schedule with milestones and include these milestones and the specified contract completion date as scheduled activities,
 3. the order in which the Work will be performed,
 4. planned dates of equipment, subsystem and system start-up and testing
 5. all interface activities requiring mutual support between the Contractor, subcontractors, suppliers, or the Employer.
 6. and shall use the schedule in planning, scheduling, directing, coordinating, and executing the Work.
- C. Scheduling software shall provide data reports or data sorts in each of the following formats:
 1. activity listing by activity,
 2. activity listing by early and late start dates,
 3. activity listing by early and late finish dates,
 4. critical path activities,
 5. activity listing by responsibility code, subcontractor, or division,
 6. activity listing by total float,
 7. computer produced time scaled logic diagram,
 8. computer produced bar chart.

- D. The Contractor's application for payment shall not be processed until the Contractor has submitted an acceptable Construction Schedule meeting the requirements of these specification.
- E. The Contractor shall adjust network logic, activity sequences, activity durations, and similar items as necessary to maintain adequate progress to ensure that the project is completed within the specified time frame. Adjustments shall account for events which include, but are not limited, to the following:
 - 1. schedule slippages,
 - 2. delays,
 - 3. sequence changes necessitated by project conditions,
 - 4. labor inefficiency.

1.03 Interim Schedule

- A. The Contractor shall submit an Interim Construction Schedule within ten calendar days of receipt of Letter of Acceptance. It shall depict work to be performed and work which is being performed during the first 90 days of the project. After approval, this shall be the Contractor's work plan for the initial 90 day period. The schedule shall be presented as a bar chart consisting of horizontal lines or bars plotted along a daily time scale. The horizontal bars shall indicate start and finish dates for each activity shown. The schedule shall be reviewed and approved by the Engineer.
- B. The Interim Construction Schedule will be superseded upon approval of the Construction Schedule described below. All activities contained in the Interim Schedule shall also be included in the Construction Schedule.

1.04 Construction Schedule

- A. The Contractor shall submit the Construction Schedule to the Engineer for approval within the period stated under Clause 14 of the Conditions of Contract. The schedule shall be used as basis for progress reporting, schedule controlling and schedule forecasting and shall be provided in sufficient detail to enable the Employer to evaluate the Contractor's planned schedule and monitor progress on a day to day basis throughout the project. The schedule shall clearly indicate all restraints and contract milestones and consist of three parts:
 - 1. computer drawn, time scaled network diagram,
 - 2. computer generated, mathematical analysis or printout,
 - 3. computer generated, off site schedule.
- B. The approved Construction Schedule shall be the Baseline Schedule against which all progress is measured. It shall also be used by both the Contractor and the Engineer as the basis for evaluating changes, claims, and applications for payment.
- C. If the Engineer rejects the Contractor's Construction Schedule, including any subsequent update or revision, the Contractor shall, within 14 days of receiving the rejection, revise the schedule to comply with the Contract Documents and resubmit it to the Engineer. Changes shall be made as directed by the Engineer even if the Engineer and Contractor cannot agree as to the revisions required.

- D. Activity durations shall be measured in calendar days. Activities shall be selected such that the duration is generally less than 21 calendar days. Activities with a duration exceeding 21 days shall be divided using logical measuring points of quantities, time or accomplishment. This limitation is not intended to impede or restrict Contractor's flexibility to properly plan and schedule the Work.
- E. The schedule shall represent an accurate, efficient, reasonable and feasible plan and method for accomplishing the Work within the number of days specified. The Engineer will review the schedule but will not be responsible for whether the schedule will result in timely project completion. The schedule shall be the Contractor's sole responsibility, including but not limited to preparation, content, revisions, and updating in accordance with the Contract requirements.
- F. The Contractor shall understand and agree that the Employer does not guarantee Work activities. If work by the Employer, or a separate contractor, is scheduled to be complete by a specific date, or within a specific duration, the Employer or separate contractor must agree to those dates in writing, or the dates are not considered valid. The Employer or Engineer's overall review and approval of the schedule does not constitute an agreement to specific dates or durations for activities of the Employer or any separate contractor.
- G. The Construction Schedule shall indicate the following:
1. on-site and off-site activities as defined elsewhere in this specification, such as deliveries, Employer's operational adjustments, start up, testing, mobilization, and demobilization, shop drawing submittals, etc.
 2. Interfaces with the work of outside contractors including but not limited to the various utilities, and the Employer's operating personnel.
 3. Activity descriptions including the activity number.
 4. The planned and remaining duration for each activity.
 5. Early start and late start dates for each activity.
 6. Early finish and late finish dates for each activity.
 7. Available float for each path of activities containing float.
 8. Actual start and actual finish dates for each activity.
 9. Identification of all critical path activities.
 10. Project critical path shall be clearly shown and easily recognizable and shall clearly show the relationship between all non-critical activities and activities on the critical path.
 11. The planned and earned monetary value of each activity and the total planned value shall equal the total contract value.
 12. The planned and earned craft and staff manpower utilization for each activity including a plot of manpower versus time for each schedule of value item and the total project.
 13. Identification as to whether the Contractor or subcontractor is responsible for performing a particular activity.
 14. The percent complete for each activity in progress or completed.
 15. Planned progress curve consisting of a plot of percent complete versus time for each schedule of value item and the total project.

- H. The Contractor shall submit a narrative report with the Construction Schedule indicating anticipated use of the following resources and work shifts:
1. Labor resources.
 2. Equipment resources.
 3. Work shifts (e.g. single, double, or triple shifts)
 4. Work weeks (5, 6, or 7 day work week)

1.05 Updates and Revisions

- A. The Contractor shall update the Construction Schedule every month to reflect the actual "as built" data. Two copies of the preceding month's Construction Schedule shall be submitted at least seven calendar days prior to submitting each monthly payment application and shall be marked with the proposed updates and revisions. The Engineer will review the marked up schedule and return one annotated copy to the Contractor for use in preparing the monthly update. The schedule up date will be used to review the Contractor's payment application. The Contractor shall submit updated schedule, reflecting Engineer's comments, with the monthly payment application. The Contractor shall indicate the following in the mathematical analysis which accompanies the updated schedule:

1. activities in progress or to be performed in the future,
2. percent complete for each activity,
3. the critical path for the project based on the latest update data,
4. the earned value for each activity.

B. Progress Reports

1. The Contractor shall submit a report with each payment application which summarizes Work progress. The format of the report shall be acceptable to the Engineer. The required information shall include, but not necessarily be limited to, the following:
 - a. work progress whether at the factory or in the field,
 - b. state existing status, rate of progress, estimated time of completion, and cause of any delay (if any),
 - c. description of Work accomplished since submission of previous progress schedule,
 - d. compare actual work status against the Contractor's previous Construction Schedule,
 - e. status of equipment and material deliveries,
 - f. changes or additions to Contractor's supervisory personnel since the preceding progress report,
 - g. causes or any delays,
 - h. changes in logic, construction sequence and activity duration including an explanation of why the changes are necessary,
 - i. proposed actions by the Contractor to restore the schedule including what is being done or what is planned to be done in each problem area.
 - j. identify anticipated problems or changes and present plan to deal with them so as to minimize or prevent delays.
 - k. construction photographs.

2. Updates and revisions to required schedules and reports shall not modify or limit, in any way, the Contractor's obligations under this Contract; including but not limited to the Contract Time, Contract Completion Dates, Contract Milestone Dates, etc.

1.06 Payment Applications

- C. The Engineer shall be under no obligation to process the Contractor's payment application until the Contractor meets the requirements of this Section.
- D. The Contractor shall furnish three copies of the updated Construction Schedule, Monthly Summary Report and the following network analysis reports with each payment application:
 1. activity listing with activity code, description, original and remaining duration, percent complete, early and late start and finish dates and float for each activity.
 2. critical path report with activities listed by most critical and early finish dates,
 3. activity listing with planned and earned values,
 4. One set of computer diskettes containing the updated construction schedule used to compute the total earnings reported in the Payment Application shall be furnished.

1.07 Requested Time Adjustment Schedule

- A. If the Contractor believes he is entitled to an extension of the Time for Completion, he shall submit a "Requested Time Adjustment Schedule" (RTAS) to the Engineer as a proposed variation order. This shall include:
 1. a separate schedule and analysis indicating proposed adjustments to the specified Time for Completion. The proposed adjustments may be due to actual or anticipated changes or delays,
 2. a time scaled, computer generated, and computer drawn network analysis schedule,
 3. a formal time extension request and detailed narrative justifying the requested time extension shall accompany the schedule.
 4. schedule forecasts that predict the actual project completion date and which forecast milestone achievement dates with the request for time adjustment.
- B. The RTAS shall clearly and accurately reflect the following:
 1. Contractor's actual Work intention and proposed time adjustments as of the latest update,.
 2. adjustments to the logic, sequence or duration of any activities in the schedule,
 3. time extensions previously granted,
 4. actual and expected progress.
- C. The Engineer shall not be obligated to consider any time extension request unless all specified contract requirements are met. The Engineer shall not be responsible or liable to Contractor for any constructive acceleration if a requested time extension is denied due to the Contractor's failure to comply with the specified submission and justification requirements. The Contractor's failure to perform in accordance with the approved

Construction Schedule shall not be excused and shall not be chargeable to the Employer as a result of the Contractor having submitted time extension requests.

- D. "Float" or "slack time" is defined as the amount of time between the early start date and the late start date or between the early finish date and the late finish date of any activity in the Construction Schedule. "Float" or "slack time" is not time for the exclusive use or benefit of either the Employer or the Contractor. Time extensions for Work required by the Contract Documents will be granted only to the extent that time adjustments for affected activities exceed the total float available along the affected path of activities, and available float will be determined at the time a change is authorized, or at the start of the condition or delay for which an adjustment is warranted under the Contract Documents.
- E. If a milestone or completion date is modified by a variation order issued by the Engineer, the Contractor shall modify his Construction Schedule accordingly. All activities impacted by the variation order shall be adjusted to reflect the revised requirements.
- F. The Contractor shall make the following available to the Engineer within seven calendar days of receiving a written request from the Engineer.
 - 1. all documents, data, etc. which support or provide the basis for schedules, reports, and project forecasts,
 - 2. Detailed calculations,
 - 3. Subcontractor documents and data.

1.08 Schedule of Off-site Activities

- A. The Contractor shall include all procurement and delivery related activities in the Construction Schedule. These activities may be submitted as a separate "Off-site Activities" Schedule upon written approval by the Engineer. Off-site activities shall be properly correlated and interrelated to the Construction Schedule. All restraints and dependent activities which may affect the Construction Schedule shall be shown.
- B. The "Off-site Activities Schedule" shall include but not necessarily be limited to:
 - 1. activities for submitting, ordering, manufacturing, fabricating, and delivering long lead items to the project site,
 - 2. significant construction related activities performed by the Contractor away from the project site, including material and equipment purchase and delivery,
 - 3. Contractor's drawings and submittals for long lead items,
 - 4. required off site inspection activities by the Employer or the Engineer.
- C. The Contractor shall be solely responsible for expediting deliveries to ensure the latest approved Construction Schedule is maintained.
- D. The Engineer shall be notified, in writing, whenever it is anticipated that delivery will be later than shown on the latest approved Construction Schedule.

1.09 Co-ordination

- A. Work at times other than the approved normal work hours requires approval by the Engineer at least 48 hours in advance of the work.

- A. A pre-approved plan (in writing) shall be required for all construction activities requiring actions by the Employer's operating personnel. Such activities requiring the Employer's personnel shall generally be related to rerouting of water service, short term interruptions or removing any existing reservoir or pipeline from service. The Contractor shall submit a written request to use the Employer's personnel to the Engineer at least seven calendar days prior to the requirement and activities shall not be scheduled outside of normal working hours. Costs associated with operating personnel provided to the Contractor, but not used for the stated purpose, shall be borne by the Contractor at the billing rate (including fringe benefits) in effect at that time.
- B. The Contractor shall submit any required traffic control, detour and staging plans at least five working days prior to blocking any streets, walks or, parking areas and such plans must be approved prior to implementation.

1.10 Engineer Interface with Scheduling System

- A. The Contractor shall provide the necessary hardware and legal software to allow the Engineer to access the Contractor's computerized scheduling system. The hardware shall be placed in the Engineer's on-site office and placed into service no later than 56 days after the Letter of Acceptance. Training shall be provided for two Engineer representatives. The Engineer's access to the Contractor's Scheduling System shall be on a "read only" basis but shall include capability for the Engineer to execute "what if" type of exercises without changing the Contractor's data.

End of Section O1310

Section 01380: Construction Photographs

Part 1 General

1.01 Description

- A. This Section includes construction photography.

1.02 Submittals

- A. The Contractor shall submit qualifications of a professional photographer and a representative 200 x 250 mm sample of the photographer's work to the Engineer for approval. The sample shall be of outdoor construction in colour.
- B. Monthly progress photographs shall be delivered with the monthly Progress Report.

1.03 Photography Requirements

- A. Sufficient photographs shall be taken prior to beginning construction to record existing conditions. Photographs shall be taken of the entire site. Two sets of prints of these photographs (200 x 250 mm) shall be provided. Each photograph shall be indexed and described.
- B. Monthly progress photographs shall be taken throughout the construction period on the cutoff date for each application for payment. One colour print (in standard photographer's binder) and negative of each photograph, for an anticipated maximum of fifty exposures per month, shall be provided. These prints shall be indexed and described. In addition eight colour presentation prints (200 x 250 mm) of each of a maximum of ten of the negatives as selected by the Engineer shall be provided each month to the Engineer.
- C. Presentation prints shall be smooth surface, matt finish, processed by an approved professional, and mounted on heavy weight A4 sized sheets. One print shall be mounted in each sheet and shall be professionally labelled, in black type-face on the front, with the following:
- i. name of project,
 - ii. contract no.,
 - iii. date,
 - iv. orientation and description of view,
 - v. name and address of photographer,
 - vi. photographer's numbered identification of exposure.
- D. Copyright of all photographs shall be vested in the Employer and all negatives shall be submitted to the Employer at the end of construction. Photographs shall not be used for any other purposes whatsoever without the Employer's approval.
- E. In addition to the above the Contractor shall provide one set of photographs in digital format, in a similar manner to that described above.

End of Section 01380

Section 01400: Quality Control

Part 1 General

1.01 Description

This Section includes:

1. Submittals.
2. General Quality Control Requirements.
3. Quality Control Plan.
4. Inspection Procedures.
5. Inspection and Test Plan.
6. Document and Submittal Control.
7. Identification and Control of Items and Materials.
8. Inspections and Tests.
9. Measuring and Test Equipment.
10. Non-Conformance Monitoring.
11. Personnel Qualifications.
12. Quality Control Audits.
13. Equipment/Material Handling and Storage.
14. Quality Control Records.
15. Workmanship.
16. Protection of Property

1.02 Submittals

- A. The Contractor shall submit a Quality Control Plan (QCP) to the Engineer no later than 56 days from the Letter of Acceptance of the Works. No work covered by the Contractor's QCP shall begin until the plan has been approved. The plan shall describe all of the Contractor's quality control procedures that will be used throughout the project and the minimum requirements shall be as specified herein.
- B. The QCP shall include the Contractor's quality control organization. It shall include the name, qualifications, and experience of the quality control manager and key support staff. Once approved, the Contractor's quality control manager shall have full authority to represent and act for the Contractor on all quality-related matters. The Contractor shall notify the Engineer in writing prior to re-assigning any of the designated quality control personnel and shall obtain Engineer's approval for replacement prior to re-assigning or re-locating approved quality control personnel.
- C. The Contractor shall submit a list of proposed suppliers and sub-contractors and which shall include the following:
 - i. items to be supplied by each supplier and sub-contractor,
 - ii. model or catalogue numbers,
 - iii. specifications,
 - iv. inspection and test requirements,
 - v. performance data,
 - vi. anticipated inspection and test dates,
 - vii. other pertinent information as appropriate.
- D. Inspection and test results, certificates of compliance, and certified material test reports shall be submitted to the Engineer as specified in Section 01300.

- E. Quality control procedures and instructions shall be submitted to the Engineer no later than 30 calendar days prior to using such procedures or instructions. Work governed by quality control procedures shall not begin until such procedures have been approved by the Engineer.
- F. A records index shall be prepared of all project records which will be developed and maintained during progress of the Work. This shall be submitted to Engineer no later than sixty calendar days from the start of the contract.
- G. Inspection and test results shall be submitted at least fifteen calendar days prior to incorporating items into the Work. Report results to the Engineer indicating compliance or failure immediately upon receipt.

1.03 General Quality Control Requirements

- A. The Contractor shall develop, implement and maintain a quality control program consistent with the requirements of this Section ensuring that equipment and materials conform to applicable requirements of each section of the specifications. Quality shall be maintained in all areas of the Work including but not limited to:
 - 1. design of temporary structures
 - 2. inspection
 - 3. testing
 - 4. packaging, shipping, handling and storage of equipment and materials
 - 5. site construction activities.
- B. Procedures shall be established to prevent deficiencies from occurring. Discrepancies shall be identified when they do occur and corrective action shall be taken. The Contractor shall instruct workmen, sub-contractors, material suppliers, and other personnel involved in the project on the correct procedures to follow.
- C. The Contractor shall assign specific responsibility for implementing the quality control program.
- D. Compliance with the specified requirements shall be systematically verified using quality control audits and the results shall be recorded.
- E. The Contractor shall assist the Engineer in auditing quality control activities. These audits may be either pre-planned, or random, as warranted by general quality trends.
- F. All work under this Contract shall be inspected and tested and records of such inspections and tests shall be maintained.
- G. The Contractor shall arrange for factory inspections and tests when required by the Contract Documents.
- H. The Contractor shall provide equipment, instruments, qualified personnel, and facilities necessary to inspect the work and perform the tests required by the contract Documents.
- I. The Contractor shall repeat tests and inspections after correcting non-conforming work until all work complies with the contract requirements. All re-testing and re-inspections shall be performed at no additional cost to the Employer.
- J. The Engineer may elect to perform additional inspections and tests at the place of the manufacture, the shipping point, or at the destination, to verify compliance with applicable Specifications. Inspections and tests performed by the Engineer shall not relieve the Contractor of his responsibility to meet the Specifications. Inspections and tests by the Engineer shall not be considered a guarantee that materials delivered at a later time will be acceptable.
- K. The Employer may, at his cost, employ the services of a specialist firm to assist the Engineer, as he may require, in any matter connected with materials, including the inspection of materials and workmanship and the witnessing of tests at any stage during the

execution and maintenance of the Works (including manufacture, where supply and installation are done by the same contractor). Such independent tests may be carried out any stage during the execution and maintenance of the Works, but they shall not relieve the Contractor of any of his own obligations under the Contract. To the extent ordered by the Engineer, the Contractor shall provide labor, plant and materials (but not special testing equipment) for direct assistance to the specialist firm in their inspection and independent testing, and for any further work of investigation and repair which the Engineer considers necessary as a result of such inspection or testing. Cost of providing labor, plant and materials as aforesaid shall be borne by the Contractor where, in the Engineer's opinion, the inspection test or further investigation shows that materials and workmanship provided by the Contractor do not comply with the specified requirements, but otherwise shall be borne by the Employer.

- L. Non-conforming materials, whether in place or not, will be rejected by the Engineer. The Contractor shall be notified in writing to correct or remove the defective material from the Works. If the Contractor fails to respond, the Engineer may order correction, removal, and/or replacement of defective materials by others. The Contractor shall bear all costs for such work.
- M. Materials accepted on the basis of a Certificate of Compliance may be sampled and inspected/tested by the Engineer at any time. The fact that the materials were accepted on the basis of a certificate shall not relieve the Contractor of his responsibility to use materials which comply with the Specifications.
- N. The Contractor shall impose all of the specified QCP requirements (including inspection and test procedures) upon suppliers and Sub-Contractors.
- O. In the event the Contractor fails to adequately perform any or all of the provisions of this Section, the Employer, at its sole discretion, reserves the right to have the Engineer perform any or all of the provisions of this Section and back-charge the Contractor for the actual cost of such work. This remedy for the Contractor's failure to perform shall be in addition to any other right or remedy available under this Contract.

1.04 Quality Control Plan

- A. The Quality Control Plan (QCP) shall provide detailed description of procedures, instructions, and reports used to ensure compliance with the Contract Documents. No construction shall begin and no requests for payment shall be processed until the Contractor's Quality Control Plan is approved.
- B. The Contractor's QCP shall include the following as a minimum:
 - 1. organization chart identifying all personnel responsible for quality control and identifying the manager of the QC program showing that the position is independent of the job supervisory staff with clear lines of authority. The QC manager shall report directly to the Contractor's corporate management. The chart shall show areas of responsibility and authority of each individual in the quality control system describing the area of responsibility and authority of each individual in the quality control system. The QC manager or designated substitute shall be present at the project site at any time the work is in progress.
 - 2. procedures for reviewing shop drawings, samples, certificates, and other submittals necessary for contract compliance including the name of all personnel authorized to sign the submittals for the contractor certifying that they comply with the contract requirements.

3. procedures used to ensure compliance with the contract documents, as well as problem identification, reporting and resolution, including a copy of forms and reports used to document quality control operations and a submittal status log listing required submittals and action required by the Contractor and Engineer.
4. a description of the services provided by outside organizations such as testing laboratories and consulting engineers.
5. a test and inspection schedule keyed to the construction schedule and following the order of the Technical Specification Sections indicating the following:
 - a. inspections and tests required,
 - b. names of responsible personnel for each segment of the Work,.
 - c. schedule for each inspection and test.
 - d. document and submittal control procedures.
 - e. procedures to identify and control use of items and materials.

1.05 Inspection Procedures

- A. As a minimum, work shall be inspected before beginning each work segment and after completing a representative portion of the work.
- B. The Contractor shall perform follow-up inspections as necessary to ensure compliance with the contract documents.
- C. Preparatory inspections shall include:
 1. review of the contract requirements,
 2. review of approved shop drawings and submittal data,
 3. check availability of required control testing,
 4. ensure equipment conform to the Specifications and approved submittal data,
 5. ensure the necessary preparatory work has been completed and is of acceptable quality.
- D. The Contractor shall perform an initial inspection as soon as a representative segment of the particular item of Work has been completed. This inspection shall include scheduled tests and results shall cite the Contract requirements, the test or analytical procedures used, and the actual test results and state whether item tested or analyzed "conforms" or "fails to conform" to the Specifications. Test reports shall be signed by the laboratory representative who is authorized to sign certified test reports. The quality of workmanship shall be examined, checks made for omissions or dimensional errors and the initial work approved or rejected.
- E. The Contractor shall provide follow-up inspections and tests at his own cost as necessary including continued testing and examinations to ensure compliance with the Contract requirements.

1.06 Inspection and Test Plan

- A. The Contractor shall develop an Inspection and Test Plan for each Specification Section identifying the following:
 1. all required inspections and tests required by that Specification Section,
 2. required testing frequency,
 3. the accept/reject criteria,
 4. records required to document compliance,
 5. procedures or instruction to be used for control of each activity.
- B. The Contractor shall provide sufficient detail to allow the Engineer and other agencies having jurisdictional authority over the work to identify operations to be inspected by that

organization. Such operations shall not be bypassed by the Contractor, unless a written waiver is given by the witnessing organization.

1.07 Document and Submittal Control

- A. The Contractor shall establish written procedures for processing all documents and submittals associated with this project. Procedures shall address receipt, filing, safeguarding, processing and transmitting. The Contractor shall establish procedures to ensure documents are prepared and transmitted or distributed in a timely manner. Procedures shall also ensure documents contain the required technical information.
- B. The Contractor shall provide quality control procedures, methods, and current documents at the locations where they are to be used.
- C. Separate files shall be maintained for quality related documents and such files shall be made available to the Engineer upon request. The Contractor shall retain all quality related records for not less than three years and shall protect all records from damage, deterioration, and loss.
- D. The Contractor shall not change or alter approved submittals, procedures, shop drawings or any other pertinent documentation without the Engineer's written authorization.

1.08 Identification and Control of Items and Materials

- A. The Contractor shall establish control procedures to ensure that items or materials accepted through shipping or receiving inspection are properly used and installed.
- B. The Contractor shall identify all items and materials so that they are traceable throughout all inspections, test activities, and records. For stored items, the identification method shall be consistent with the expected duration and type of storage.
The Contractor shall record equipment and material identifications and ensure that they are traceable to the location where they are incorporated into the work.
- C. The Contractor shall develop and maintain a receiving/inspection log containing at least the information itemized below:
 - 1. purchase order number,
 - 2. item number,
 - 3. suppliers name,
 - 4. quantity,
 - 5. item description,
 - 6. reference to applicable contract requirements,
 - 7. date received,
 - 8. serial number or other Identification, as applicable,
 - 9. verification of receipt of all required supporting documentation,
 - 10. QC acceptance sign-off and date,
 - 11. nonconformance number, if applicable.

1.09 Inspection and Tests

- A. The Contractor shall use an approved material testing laboratory for testing required by these specifications at his cost. An on-site laboratory staffed by qualified personnel may also be used if allowed by the Engineer. The name and qualifications of independent testing laboratories shall be submitted to Engineer for approval no less than thirty calendar days prior to the date the laboratories are to be used. Once approved, dismissal and replacement

of the approved independent testing laboratory shall require written authorization by the Engineer.

- B. All inspections and tests shall be conducted in accordance with written test procedures that have been reviewed and approved by the Engineer. The Contractor shall have adequate QC personnel on site during all production shift operations. Test procedures submitted for approval shall include the following, as a minimum:
 - 1. prerequisites for the given test,
 - 2. required tools, equipment, and instrumentation,
 - 3. necessary environmental conditions,
 - 4. acceptance criteria,
 - 5. data to be recorded,
 - 6. test results reporting forms,
 - 7. identification of items tested.
- C. Inspection and testing work shall be performed by personnel designated by the Contractor. Such personnel shall not be the same as those that performed the work.
- D. Approved procedures and instructions shall be “on hand” and used by inspection and test personnel at the time of inspection or test. All revisions shall be approved prior to being used to inspect or test the work. No deviations from approved work procedures and instruction shall be allowed without written authorization from the Engineer.
- E. The Contractor shall provide the Engineer with not less than 48 hours written notice of the occurrence of an assigned test point. Any test point inspected by outside agencies shall require a minimum 14 days prior written notification. The Engineer reserves the right to select a different test point at any time.
- F. The Contractor shall submit inspection/test results to the Engineer prior to incorporating the item(s) into the work. Inspection/test failures shall be reported to the Engineer immediately upon receipt and certificates of compliance shall be submitted 15 days prior to incorporating a product to the Works.
- G. Inspections and tests conducted by persons or agencies other than the Contractor, shall not in any way relieve the Contractor of his responsibility and obligation to meet all Specifications and referenced standards.
- H. Inspection and test records shall, as a minimum, identify the following:
 - 1. name of items inspected/tested,
 - 2. quantity of items,
 - 3. inspection/test procedure reference,
 - 4. date,
 - 5. name of inspector/tester,
 - 6. observations/comments,
 - 7. specified requirements,
 - 8. acceptability,
 - 9. deviations/non-conformances,
 - 10. corrective action,
 - 11. evaluation of results,
 - 12. signature of authorized evaluator.

- I. The Contractor shall clearly document and identify the inspections and test status of materials and equipment throughout construction. Identification may be by means of stamps, tags, or other control devices attached to, or accompanying, the material or equipment.

1.10 Measuring and Test Equipment

- A. The Contractor shall provide measuring and test equipment necessary to ensure construction conforms to the requirements of this specification.
- B. The Contractor shall maintain the accuracy of all measuring and test equipment and shall provide a unique identification number or mark permanently affixed to each item of measuring and test equipment. Each item of measuring and test equipment shall be calibrated at intervals recommended by the manufacturer. The Contractor shall develop a log of all measuring and test equipment and record:
 1. equipment description,
 2. identification number,
 3. date of the last calibration,
 4. date that the next calibration is due.

1.11 Non-conformance Monitoring

- A. The Contractor shall develop a system to identify, document, control and process non-conforming material and equipment. A non-conformance exists when, either material and equipment, documentation, or construction, do not comply with the requirements of the Contract Documents. The monitoring system shall apply to material and equipment as well as installation and construction which fails to conform to the Contract Documents.
- B. The Contractor shall provide the engineer with the following information for each non-conformance:
 1. identification of non-conformance,
 2. description of non-conformance,
 3. evaluation of non-conformance to establish the cause,
 4. recommended corrective action,
 5. date non-conformance was identified,
 6. date corrective action was completed,
 7. description of final corrective action.
- C. The Contractor shall develop and maintain a non-conformance log to track all non-conformances. The log shall contain the following information as a minimum:
 1. sequential reference number,
 2. date issued,
 3. originator,
 4. description of item deemed to be in non-conformance,
 5. description of non-conformance,
 6. recommended and final disposition,
 7. date closed,
 8. Contractor's QC Manager's initials,
 9. remarks, as applicable.

- D. The Contractor's QC personnel shall have the authority to stop that portion of the work which does not comply with the Contract requirements.
- E. The dispositions for non-conforming items and materials shall be subject to approval by the Engineer.
- F. The Contractor shall clearly identify each non-conforming item with a distinguishing mark and shall establish procedures for installing, monitoring, and removing these marks after approval of the Engineer. The Contractor shall identify personnel authorized to remove these marks.
- G. The Contractor shall take prompt action to identify the causes of each non-conformance and the corrective action necessary to prevent recurrence. The results of failure and discrepancy report summaries, supplier evaluations, and any other pertinent applicable data shall be used for determining corrective action. Information developed during construction, tests, and inspections, that support the implementation of required improvements and corrections shall be used to support the adequacy of corrective action taken.

1.12 Personnel Qualifications

- A. The Contractor shall identify activities requiring qualified production, inspection, and test personnel and establish their minimum competence level. The Contractor shall maintain records of personnel qualifications as quality records.
- B. Personnel inspecting and testing special operations (e.g., welding, brazing, etc.) shall have the experience, training, and certification commensurate with the scope, complexity, or nature of the activity. Such personnel shall be approved by the Engineer.
- C. The Contractor shall submit the following for all such production, inspection and test personnel:
 - 1. qualifications description,
 - 2. orientation,
 - 3. skill evaluation,
 - 4. certification credentials.

1.13 Quality Control Audits

- A. The Contractor shall perform regularly scheduled internal audits to verify that his quality control procedures ensure total compliance with the Specifications and referenced standards. Quality control audits shall be scheduled not less than monthly. The Contractor shall maintain records of these audits as quality records and make them available to the Engineer upon request. The Engineer shall be provided with access to the audit records upon request. The Contractor shall allow the Engineer to observe the Contractor's internal audit upon request.

1.14 Equipment/material Handling and Storage

- A. The Contractor shall be responsible for all handling, storing and preserving equipment and material from the time of receipt to the time of acceptance by the Employer. The Contractor's storage and handling procedures shall be designed to prevent damage, deterioration, distortion of shape or dimension, loss, degradation, loss of identification, or substitution. The handling procedures shall address the use, inspection and maintenance of special devices such as crates, boxes, containers, dividers, slings, cranes, material handling and transportation equipment and other facilities. The Contractor shall identify equipment and material requiring special handling or testing.

1.15 Quality Control Records

- A. The Contractor shall develop a complete records index based on the requirements for document and data submittals in each Section of these Specifications. The Contractor shall indicate all quality control records, documentation, submittals and data required by the Contract and shall supplement these records as necessary to monitor quality throughout the project. The records identified in the index shall provide objective evidence that quality control program activities conform to the contract requirements including evidence that required verifications have been performed. The Contractor shall authenticate all records. Only complete and properly authenticated documents shall be maintained as records of material and equipment quality.
- B. Quality records shall be indexed, filed and maintained in a manner that provides for timely retrieval; traceability, easy identification and the latest status (acceptability) of equipment and material and shall be protected from deterioration and damage. As a minimum, records shall include:
 - 1. name of equipment/material inspected/ tested;
 - 2. specification reference by section and paragraph (where applicable);
 - 3. quantity of items;
 - 4. location and installation;
 - 5. inspection/test procedure reference;
 - 6. date;
 - 7. signature of inspector;
 - 8. observations/comments.

1.16 Workmanship

- A. The Contractor shall comply with industry standards except when more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.
- B. Work shall be performed by persons qualified to produce workmanship of the specified quality.
- C. Products shall be secured in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking.
- D. The Contractor shall comply with manufacturer's published installation instructions in full detail, including each step in sequence. Should instructions conflict with Contract Documents, clarification shall be requested from Engineer before proceeding.

1.17 Protection of Property

- A. The Contractor shall not load or permit a structure to be loaded in a manner that will endanger the structure and shall not subject Work or adjacent property to stresses or pressures that will endanger it.
- B. The Contractor shall take positive action to protect existing surfaces and facilities from damage resulting from construction operations unless modifications to the surfaces or facilities are required as part of the Contract. All features and facilities shall be protected from damage caused by mobile and stationary equipment, including vehicles delivering materials to the project site. Finished surfaces, including jambs and soffits of openings used as passageways through which materials are handled, shall be protected against possible damage resulting from the conduct of the work by trades. The Contractor shall provide and maintain adequate protection for adjacent structures. When required by law or for the safety of the Work; shore, brace, underpin, or otherwise protect those portions of adjacent structures that may be affected by the Work.
- C. Known utilities and related facilities are shown on the drawings but location of these facilities are not guaranteed, nor is there any guarantee that other utilities are not present. Unless otherwise specifically provided, the Contractor shall protect utilities and related facilities from damage and cause no interruption of service. The Contractor shall establish and maintain direct contact with the owner or operator of each utility that may be affected by the Work and shall proceed with Work that may affect a utility only with the cooperation and approval of the owner or operator of the utility. The Contractor shall immediately inform the Engineer of any agreement with the utility operator concerning the Work under this Contract. The Contractor shall verify the location of all utilities in the vicinity of the work by actual field measurements before commencing construction and shall submit a plan for performing the work to the Engineer for approval including evidence of approval by the utility owner or operator.
- D. All finished surfaces shall be clean and un-marred upon acceptance of the structure. The Contractor shall not permit traffic or material storage on roof surfaces. Where some activity must take place on the roof in order to perform the Work, the Contractor shall provide and maintain adequate protection. Adequate protection shall be maintained against the weather at all times so as to preserve Work, materials, equipment, apparatus, and fixtures free from injury or damage. The Contractor shall not use items of equipment that are intended to form a part of the completed work as construction equipment without specific approval from the Engineer in each instance.
- E. The Contractor and the Engineer shall conduct a pre-construction inspection of existing facilities and structures in the vicinity of the Work and the Contractor shall document the inspection by photographs, sketches, and narratives assembled into an inspection report. The inspection report shall be signed and dated by the Engineer, indicating agreement that the report represents an accurate description of the existing conditions. The Contractor shall establish reference points on or about any structure that may be affected by excavation performed as part of this contract. Reference points shall be sufficient to detect any horizontal or vertical movement which may occur. Points shall be accurately referenced to a stable benchmark remote from the Work. The Contractor shall accurately survey reference points at least weekly during excavation in the vicinity. Prior to beginning excavation, a detailed description of the proposed movement detection system shall be submitted to the Engineer for approval. Submit a copy of each survey of the movement detection system to the Engineer within 24 hours after the survey is completed.

- F. The Contractor shall repair damage as soon as possible after discovery for those surfaces and facilities which are to remain in place. Repairs shall be as strong as the undamaged item. Repaired surfaces shall be identical in color and texture to the adjacent existing materials. Where materials cannot be matched, refinish the surrounding area to give a uniform appearance acceptable to the owner and Engineer. The Contractor shall replace damaged shrubs, vegetation, and trees outside the clearing limits that are damaged by construction operations. Replace trees larger than 75 mm in diameter measured at a height of 1 m above ground with trees 75 mm in size. Replace all other vegetation with the same species and size as that damaged, unless otherwise approved by the Engineer.

End of Section 01400

Section 01450: Health and Safety

Part 1 General

1.01 Safety and Security

A In addition to any requirements as set down in the General Conditions of Contract the Contractor shall at all times maintain a safe system of working and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by his work.

B In particular he shall ensure that only persons who are properly trained for their duties are employed, and that the correct tools and procedures are used.

C Not later than 28 days after the Letter of Acceptance of the Works, the Contractor shall submit to the Engineer his comprehensive proposals relating to the safety, health and welfare of all his personnel on the Site.

D In addition to any requirements as set down in the General Conditions of Contract, the Contractor shall be responsible for the implementation of safety related site procedures which shall include but not be limited to:

- Safety
- Working in hazardous areas
- Permit to work
- Fire and smoking regulations
- First aid
- Warning signs
- Trenching scaffolding and other construction structures
- Safety barriers
- Protective clothing and equipment
- Safety training
- Safety meetings and inspections
- Health and welfare

E The proposals shall be appropriate for all grades of labour and personnel who will work on or visit the Site on behalf of the Employer, Engineer or Contractor.

F The Engineer shall have the power to stop any activity or work in any area where there is a breach of the published site safety rules such that health or life is put at risk.

G The Contractor shall, in addition, comply with the Safety Policy of the Employer, copies of which are available on request from the Engineer.

1.02 First Aid and Life-saving Apparatus

The Contractor shall provide on the Site such life-saving apparatus as may be appropriate and an adequate and easily accessible first aid outfits. In addition, an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on Site.

1.03 Electrical Safety

A The Contractor shall be responsible for the electrical safety of all Plant supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on site. If necessary, this shall include fencing off areas which are considered to pose a risk, and erecting warning notices.

B The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained competent personnel and that the work is carried out in a safe manner.

C The Contractor shall be responsible for the operation on the Site of a permit to work system during the period of electrical equipment installation and testing. This system shall regulate the installation, the energising and the use of electrical Plant installed and the method of work adopted.

D Power hand tools for use on site shall operate at no greater than 110 V (55-0-55 V).

1.04 Warning and Safety Signs

Statutory safety signs in accordance with ISO 3864, shall be adequately provided throughout the Site, both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire fighting and general notices. All signs shall be positioned around the Site at highly visible points. Provision of signs, and the positions of signs shall be subject to the Engineer's approval. Special attention shall be given to areas designated hazardous.

1.05 Hazardous Material Identification

A. There may be hazardous materials supplied as part of this Work. The Contractor shall be alert to potentially hazardous materials even though the materials may be located outside the construction area or in an area not normally accessible to the Contractor or his employees. Neither the requirements of this clause nor an act or failure to act by the Employer or the Engineer shall relieve the Contractor of responsibility and liability for the safety of Engineer, Employer, Contractor, or subcontractor personnel and property.

B. Hazardous materials may include, but are not necessarily limited to, petroleum and associated by-products, paints, thinners and other such construction materials together with those chemicals used in the operation of the facilities to be constructed.

C. The Contractor shall ensure that all containers of substances belonging to the Contractor and his Subcontractors that are on-site or in storage are properly labeled as to the contents and the potential hazard (if any). The Contractor shall submit a Material Safety Data Sheet (USA Department of Labor Form OSHA-20), or the local equivalent, for all hazardous material brought to the project site at least five days before delivery.

1.06 Guidelines to Safety In Sewers And Sanitary Structures

- A. The Contractor shall be aware of the guidance and provisions contained in 'Safe Working in Sewers and at Sewage Works' published by the United Kingdom National Joint Health and Safety Committee for the Water Service.
- B. The Contractor must inform his work force of the:
1. hazards of inflammatory or otherwise noxious volatile liquids being discharged into sewers. Some of these may produce vapours which can cause irritation to the eyes, nose or skin. Should the presence of such liquids be suspected, suitable precautionary measures shall be taken.
 2. danger of bacterial infection while working in a sewage contaminated environment and shall impress upon them the importance of personal hygiene.
- C. 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.
- D. The Contractor shall be responsible for ensuring adequate precautions are taken by his workforce to safeguard against any accidents to whosoever while working in or adjacent to sewers, sewage works, manholes, pumping stations, etc.
- E. All members of the workforce shall be vaccinated against tetanus, typhoid and para-typhoid and the Contractor must have up to date medical records of each person. The Contractor shall provide a medical certificate of fitness each of his personnel. Should any one working in a manhole, sewer or chamber, complain of nausea or dizziness then all personnel should be removed from that location and work should resume only when it is safe to do so, or with the use of breathing apparatus under site supervision of safety officer.
- F. All members of the workforce shall be fit and everyone who will be expected to work in sewers shall not suffer from:
1. any heart defect,
 2. any history of fits or blackouts,
 3. deafness or loss of balance,
 4. claustrophobia,
 5. recurrent back ailments,
 6. shortage of breath on light exertion.
- G. The Contractor shall safeguard his workforce against dangers of toxic, asphyxiatory, inflammable or explosive gaseous conditions in manholes, sewers and ancillary structures and physical injury, caused by falling objects, or by falling themselves.
- H. Each group of workers engaged on sewers, manholes, pumping or lifting stations and ancillary structures shall be provided with and be familiar with the operation of reputable gas testing equipment suitable to check hydrogen sulphide combustible gases and lack of oxygen.
- I. Precautions to be taken include, but not by way of limitation, the provision for each person working in sewage works of:
1. safety helmet,
 2. safety boots with no ferrous studded soles,
 3. safety belt (strong readily washable with no ferrous attachments for lifeline),
 4. gloves,
 5. overalls.

- J. In addition to the above items, each group shall have with them at each entry point to a confined space of the following:
1. a lifting harness,
 2. 4 No. 15 metre life lines with spring shackle one end, eye at other,
 3. ladder,
 4. lifting frame complete with ropes and shackles for hand operation,
 5. powerful hand lamp, with flameproof switch,
 6. ventilation blowers together with portable generator and flexible trunking,
 7. positive pressure respiratory face masks with associated portable compressor and air hoses,
 8. gas detectors (suitable for H₂S),
 9. radio activity detectors,
 10. an atmosphere monitoring device capable of monitoring oxygen levels and levels of toxic and flammable gas,
 11. washing facilities with disinfectants and toiletries,
 12. communication facilities.
- K. Before entering any manhole, sewer and ancillary structure the atmosphere shall be tested as mentioned.
- L. The Contractor shall also test for radioactivity and any increase found abnormal shall be reported immediately to the concerned authorities and all works in the vicinity must be stopped.
- M. The Contractor shall provide, erect and maintain, adequate scaffolding, ladders, etc., required for work and to facilitate the Engineer's Representative to inspect and test. These shall be removed as directed upon completion of all works.
- N. The Contractor shall be solely responsible for liability in respect of any claim or legal action arising as a result of an accident and shall not be absolved of any liability under the contract in respect of his having complied with the above requirement.
- O. The Contractor shall appoint a safety officer who shall be responsible for ensuring that the Contractor's employees follow the safety procedures. The safety officer shall ensure that at least one person in each gang shall be instructed rescue procedures, resuscitation techniques, basic first aid and the use of gas detection apparatus.
- P. A mobile mess room with washing and changing facilities shall be provided by the Contractor for each working area.
- Q. The Contractor shall keep installed in the mobile changing rooms, or mobile office, within easy access of each working group emergency equipment which shall include, but not by way of limitation:
1. barrier cream,
 2. disinfectant,
 3. first aid kit with eye bath,
 4. stretcher,
 5. 15m long lifelines with spring shackle one end, eye at other, lifting harnesses,
 6. breathing apparatus with air bottle - 2 sets.

- R. Address and telephone number of the nearest hospital with emergency facilities shall be posted in each mess room.
- S. The Contractor shall provide safety barriers to be erected around all unattended open manholes and cover them with suitable temporary steel sheets. Whenever the Contractor's workforce leaves the site of the works all manhole covers shall be replaced.

End of Section 01450

Section 01500:Construction Facilities and Temporary Controls

Part 1 General

1.01 Description

This Section includes

- 1 Field Offices
- 2 Roads
- 3 Electricity and Site Lighting
- 4 Ventilation
- 5 Telephone Service
- 6 Potable Water
- 7 Sanitary Facilities
- 8 Barriers
- 9 Enclosures
- 10 Protection of Installed Work
- 11 Site Security
- 12 Water Control
- 13 Cleaning During Construction

1.02 Submittals

Working drawings showing proposed locations, access and sizes of offices, workshops, storage areas, fencing, temporary stationary equipment, and similar facilities together with connections to utilities shall be submitted to the Engineer for approval in accordance with Section 01300.

1.03 General Utility Requirements

The Contractor shall provide and maintain temporary and interim utility services necessary for performance of the Work. Installation and maintenance of utilities shall comply with applicable codes, safety and utility company requirements. Connections to the Employer's utilities shall only be with the approval of the Employer and the Engineer. Meters shall be provided for all connections to Employer's utilities and the Contractor shall pay all costs for these utilities.

1.04 Site Offices

The Contractor shall provide separate, temporary, furnished and equipped site offices on the construction site for the Engineer and site supervision staff. They shall be provided at the start of construction and remain until the issue of the Defects Liability Certificate for the whole of the Works. The offices shall be located in an area acceptable to the Engineer and shall be as specified in the Particular Specifications. All offices shall be weather-tight, with lighting, electrical outlets, air conditioning and ventilation equipment, sanitary facilities and furniture. All costs to install and maintain the Engineer's site offices including, but not limited to, air conditioning, lighting, utilities, pest control and cleaning shall be paid by the Contractor and shall be included in the Contract price.

1.05 Storage Sheds for Tools, Materials and Equipment

The Contractor shall provide weather tight storage sheds with ventilation or air-conditioning, as necessary, for products requiring controlled climatic conditions. Adequate space and lighting shall be provided for organized storage, access and inspection.

1.06 Roads

The Contractor shall use established roads or routes approved by the Engineer and shall review traffic restrictions with authorities having jurisdiction and obtain the required approvals. Roads shall be maintained free of dirt, trash, construction debris, etc. and provided with traffic controls as required and as specified in Section 01570.

1.07 Electricity and Site Lighting

The Contractor shall provide all electrical services required for offices and construction operations including branch wiring and distribution boxes as necessary, terminations for each voltage supply complete with circuit breakers, disconnect switches and other electrical devices as required to protect the permanent power supply system. The Contractor shall pay for all power used for construction operations.

1.08 Ventilation

Ventilation shall be provided to maintain specified conditions for construction operations and to protect materials and finishes from damage due to temperature or humidity. The Contractor shall verify ventilation equipment is properly installed, ready for continuous operation, and that filters are in place prior to operating permanent facilities for temporary purposes.

1.09 Telephone Service

Telephone services shall be provided to the Engineer's site office as specified in the Particular Specification.

1.10 Potable Water

Potable water services shall be provided as necessary for construction operations and the Contractor shall pay for all costs. The Contractor shall also provide, maintain and supply bottled water, including dispensers for cooling and heating the delivered water, for the Engineer's site offices.

1.11 Sanitary Facilities

Sanitary facilities shall be provided and maintained for the Engineer's site office as well as for construction personnel. Any existing facilities shall not be used by construction personnel.

1.12 Barriers

Barriers shall be provided to prevent public entry to construction areas; protect existing facilities and adjacent properties from damage; to prevent damage to trees and plants; to protect traffic

from open trenches; to protect pedestrian and vehicular traffic; to protect stored materials and to prevent puddling or running water.

1.13 Enclosures

Temporary, weather-tight enclosures shall be provided for openings in exterior surfaces to ensure acceptable working conditions, to protect installed materials and equipment, and to prevent unauthorized entry.

1.14 Protection of Installed Work

Temporary protection shall be provided for installed products and traffic shall be controlled in the immediate area to minimize damage. Walls, projections, jambs, sills, and soffits of all openings shall be covered and finished floors and stairs shall be protected from traffic, movement of heavy objects, and storage damage. Traffic and material storage shall be prohibited on waterproofed and roofed surfaces, and on lawn and landscaped areas.

1.15 Site Security

A security program shall be established and necessary facilities provided to protect the Work.

1.16 Water Control

The Site and excavations shall be maintained free of water by use of grading and/or provision, operation and maintenance of necessary pumping and dewatering equipment.

1.17 Cleaning During Construction

The Contractor shall control the accumulation of waste materials and rubbish and periodically dispose of legally at an off-site location. All interior surfaces shall be cleaned prior to starting finish work. All areas shall be maintained free of dust and other contaminants during finishing operations.

1.18 Removal of Temporary Items

Temporary materials, equipment, etc. shall be removed prior to substantial completion of the works and damage caused by installation or use of temporary facilities shall be repaired. Underground installations shall be removed to a depth of 600 mm and the areas graded to match adjacent areas.

1.19 Rodent and Pest Control

The Contractor shall keep the work area, including all storage areas, free from rodents, noxious pests, and other vermin at all times. The Employer or the Engineer shall notify the Contractor of any noncompliance and the corrective action required. The Contractor shall take immediate corrective action upon receiving such notice and if the Contractor fails to eliminate both the rodents and/or pests and the causes thereof, the Employer may have the rodents and/or pests exterminated and charge the cost to the Contractor.

End of Section 01500

Section 01570: Traffic Control

Part 1 General

1.01 Description

This Section includes traffic control requirements and dust control.

1.02 Submittals

Comply with requirements specified in Section 01300.

1.03 General Traffic Control Requirements

- A. The Contractor shall maintain and protect vehicular and pedestrian traffic through all construction areas. Work shall include, but not necessarily be limited to, temporary detours, furnishing, erecting and maintaining temporary traffic control devices including barriers, barricades, cones, drums, warning signs, traffic signals, radio communications, lights and flagmen.
- B. No work shall be performed during the hours of darkness unless otherwise authorized in writing by the Engineer.
- C. The Contractor shall ensure that adequate access is maintained at all times to properties and facilities affected by construction activities. All access ways shall be replaced with the same width, standard and surface type as the existing access facilities. The access locations to be maintained may not be shown on the Drawings. All existing access ways; whether public or private, paved or unpaved, shall be maintained at all times during the contract period unless specifically authorized otherwise by the Engineer in writing.
- D. If detours are proposed by the Contractor, a written plan and drawings shall be submitted for approval by the Engineer and traffic police. Detour work shall include but not necessarily be limited to:
 - 1. field surveys,
 - 2. construction and maintenance of paved and unpaved detour carriageways including earthwork,
 - 3. providing and installing metal beam guardrails, barriers, drainage, lighting, traffic signals, signs, barricades, and other traffic control devices,
 - 4. temporary protection of existing utility services as required by the concerned Service Authority or company,
 - 5. restoration of the Detour sites to their original condition (or such other condition as directed or approved by the Engineer) when the Detours are no longer required.

1.04 Quality Assurance

- A. The Contractor shall provide a competent Traffic Safety Supervisor, who shall be available at all times, to oversee the safety and maintenance of vehicular and pedestrian traffic operations. The supervisor shall have received traffic safety training or shall have had previous experience regulating traffic flow through construction work areas.

- B. The Traffic Safety Supervisor's duties and responsibilities shall include but not necessarily be limited to the following:
1. maintain traffic flow through and around the construction site as required by these Contract Documents,
 2. coordinate traffic control procedures with all relevant authorities, including the traffic police,
 3. inspect the condition and location of traffic control devices to ensure that they are in proper working order, clean, visible and conform to these specifications,
 4. establish traffic control requirements and develop the appropriate control procedures,
 5. provide and maintain such devices as are necessary for safe and efficient traffic movement and ensure that these devices are in place at the required time and removed when no longer required,
 6. coordinate traffic control operations, including maintenance, with the Engineer,
 7. review the Contractor's construction plan and material delivery, storage and handling procedures with respect to traffic safety and operation,
 8. conduct an initial traffic safety meeting with Contractor and any Subcontractors prior to beginning construction to review traffic control procedures, safety, etc.,
 9. conduct periodic meetings, at least monthly thereafter, to review traffic control problems and implement solutions and provide the Engineer with minutes summarizing all discussions.
- C. Flagmen when provided or required shall be physically and mentally qualified, trained in their duties, and courteous. Each flagman on duty shall wear appropriate reflective and distinctive apparel as approved by the Engineer and shall be equipped with a STOP/GO sign and radio communications, as appropriate.

1.05 Dust Control

- A. The Contractor shall prevent nuisance conditions from developing as a result of dust and dust shall be controlled by watering using tanker trucks with spray attachments or by other approved methods as often as needed and as directed by the Engineer.

Part 2 Products

2.01 Materials and Equipment

All traffic control devices shall be approved by the Engineer before being used on the Site. All sign panels, barricades, drums, vertical panels and flagmen's paddles shall be reflectorized. Painting shall not be considered as an approved substitute for reflectorization. Barricades shall be made of metal, wood or plastic and shall collapse when tipped over. Cones shall be manufactured of a material capable of withstanding impact without damage to the cones or vehicles. All cones shall be red or orange and shall have a white reflectorized band and shall be capable of remaining upright during normal traffic flow and wind conditions in the area where they are used. Vertical panels shall be constructed of metal or plastic. Warning lights shall be Type A (low intensity flashing), or Type C (steady burn) and shall meet the minimum requirement of the Institute of Transportation Engineers "Standard for Flashing and Steady-Burn Barricade Warning Lights".

Part 3 Execution

3.01 Application of Traffic Control Devices

- A. The Contractor shall provide and maintain traffic control devices, both inside and outside the Contract Limits, as needed to direct traffic and ensure vehicular and pedestrian safety. Prior to beginning construction, the necessary signs, barricades, and other traffic control devices shall be erected. All warning signs except those required for public safety during non-working hours or when construction in that area is completed shall be removed or covered with either metal or plywood sheets so that the entire sign cannot be seen by on-coming traffic. Traffic control devices shall be used for only as long as they are needed.
- B. Reflective materials on signs, drums, barricades, and other devices shall be kept clean, free from dirt, mud and road grime. Scratches, rips, and tears in the sheeting shall be promptly repaired by the Contractor to the Engineer's satisfaction. Reflective sheeting materials shall maintain a reflectivity of not less than 50 percent of their design intensity values.
- C. Warning lights shall be securely fixed to barricades or drums used singly or in combination with other devices, unless otherwise specified.

End of Section 01570

Section 01580: Project Identification Signs

Part 1 General

1.01 Description

This Section includes Project Identification Sign and sign maintenance and removal.

1.02 Quality Assurance

The signs and structure shall be designed to withstand the wind speed specified for the project site. Paint selection and application shall be adequate to withstand weathering, rain and high humidity, fading and chipping for the contract period. Signs shall be painted by a professional sign painter.

1.03 Submittals

Shop drawings of the project identification signs and samples of the proposed sign painters work shall be submitted for approval in accordance with Section 01300.

1.04 Project Identification Sign

The size and locations shall be as shown on the Drawings. The signs shall include names and logos of Employer, Funding Agency, Engineer, and Contractor; project title and contract reference.

Part 2 Products

2.01 Sign materials

The signs shall be a plywood or fibreglass mounted on a steel frame or concrete posts with concrete foundations. Paint shall conform to Section 09900 and be exterior grade primer with two finish coats.

Part 3 Execution

3.01 Erection, Maintenance and Removal

- A. The Contractor shall erect the project identification signs not later than 35 days after the Letter of Acceptance of the Works.
- B. The Contractor shall keep all signs clean, repair them if damaged and repaint them as necessary to maintain a neat and visually pleasing appearance throughout the construction period. Signs shall be replaced if missing for any reason.
- C. The Contractor shall remove the signs and structure, and repair ground disturbed during removal to its original condition, within 28 days of completion of the works.

End of Section 01580

Section 1600: Materials and Equipment

Part 1 General

1.01 Description

This Section includes:

- 1 Products;
- 2 Transportation, delivery, receiving and handling;
- 3 Storage and protection;
- 4 Products list;
- 5 Substitutions;
- 6 Product acceptance.

1.02 Products

- A. The term "product" shall mean any material including proprietary goods, equipment and manufactured items that is incorporated into the final Works. It does not include machinery and equipment used for the preparation, fabrication, conveying and erection of the Works.
- B. Products of a similar nature shall be standardized, interchangeable and supplied by the same manufacturer as far as is possible.
- C. Products shall be new and shall comply with specifications and referenced standards as minimum requirements.

1.03 Transportation and Handling

- A. Products shall be transported and handled so as to avoid product damage. They shall be delivered dry and in undamaged condition in the manufacturer's unopened containers or packaging. Detailed transportation and handling requirements specified in individual Specification Sections shall be complied with.
- B. Shipments shall be inspected upon delivery to ensure that the products comply with the requirements of the Contract Documents, are undamaged and the quantities are correct.

1.04 Storage and Protection

- A. Products shall be stored in accordance with manufacturer's instructions, with seals and labels intact and legible. Sensitive products shall be stored in weather-tight enclosures with temperature and humidity ranges maintained as required by manufacturer's instructions.
- B. Exterior storage of fabricated products shall comprise sloped supports above ground with products subject to deterioration and those which must be kept dry entirely, covered with impervious sheeting and provided with ventilation to prevent condensation.
- C. Loose granular materials shall be stored on solid surfaces in a well drained area and mixing with foreign matter shall be prevented.

- D. Products shall be stored so as to allow ready access for inspection. Products shall be periodically inspected to ensure that they are undamaged and that they are maintained under required conditions.
- E. At all times the Engineer shall have access to, and may inspect any or all stored products and will notify the Contractor of unacceptable storage methods, protection or packaging.

1.05 Products List

- A. The Contractor shall submit four copies of a list of all products to be supplied by him and which are proposed for installation not later than 60 calendar days after the Letter of Acceptance including the name of manufacturer and supplier, the trade name, and the model number of each product if applicable. The product list shall be arranged according to Specification Section number including the specification title and the paragraph designation.
- B. The Contractor shall ensure that the listed products comply with the requirements of the Contract Documents.
- C. The Engineer will notify the Contractor in writing of any product deemed to be unacceptable. Notification shall be made no later than 30 days after submission of the products list. The Engineer's objection or failure to object to a listed item shall not constitute a waiver of the requirements of the Contract Documents.

1.06 Substitutions

- A. The Contractor must submit requests for substitution within 60 days after the Letter of Acceptance. After that date, substitutions will only be considered when a product becomes unavailable from the manufacturer due to no fault of the Contractor. The Contractor shall document each request with complete data substantiating that the proposed substitution complies with the Contract Documents.
- B. A request for substitution constitutes a representation that the Contractor has investigated the proposed product and has determined that: it meets or exceeds, in all respects, the specified product; will provide the same warranty for the substitution as the specified product; will coordinate the installation requirements of the substitution and will make all changes necessary for the Work to be complete in all respects. The costs of such changes shall be at the Contractor's sole expense and the Contractor waives claims for additional costs resulting from the substitution which may subsequently become apparent.
- C. Substitutions will not be considered when such substitution is indicated or implied on shop drawing or product data submittals without separate written request complying with the above requirements or when acceptance will require substantial revisions to the Contract Documents.
- D. The Engineer will determine the acceptability of the proposed substitution and will notify the Contractor of acceptance or rejection in writing within a reasonable time.
- E. Only one request for substitution will be considered for each product. When substitution is not accepted, the Contractor shall provide the specified product.

1.07 Product Acceptance

- A. All products shall be tested as required by the Specification and shall be by an approved independent laboratory or a recognized testing organization, when required either by the Specifications or the Engineer. Such tests by the manufacturer or the supplier will not generally be acceptable. The Contractor shall be responsible for all costs associated with product testing including labor, transportation and the cost of the test itself and certifications required by the specifications.
- B. Testing samples shall be taken at the place of origin, place of fabrication or from the site as required by the Engineer. Samples that are of value after testing shall remain the property of the Contractor. Samples used for testing may only be incorporated into the Work with the written approval of the Engineer.
- C. The Contractor shall provide all necessary facilities required for on-site testing of products and shall ensure that products are made available for testing sufficiently in advance of intended use so as to allow time for testing. Delays resulting from the time taken to test a product shall not be acceptable as cause for a claim.
- D. Prior to final inspection, all components, systems and subsystems, shall be tested to demonstrate compliance with the specified performance requirements. Such testing shall be as specified in Section 01670.

End of Section 01600

Section 01650: Starting of Systems/Commissioning

Part 1 General

1.01 Description

This Section includes requirements for system and facility startup. Exceptions to these requirements are in individual technical sections and only modify the individual article and topic. Other articles and topics in this section remain in force unless specifically deleted by the Technical Section.

1.02 Definitions

“Component” means an individual item, piece of equipment, or equipment group as specified in a single section of these specifications.

“Startup Plan” means a single and complete plan incorporating all requirements of this Section.

“Subsystem” means a grouping or assembly of components, all of which operate together to produce the specified performance.

“System” means an assembly of subsystems and components.

“Validate” means to support, substantiate, and authenticate specified operation on a sound and authoritative basis.

1.03 Quality Assurance

- A. A pre-startup conference shall be scheduled not less than 15 calendar days prior to beginning start-up. The Employer, Engineer, Contractor and other responsible parties (e.g. equipment manufacturers) shall attend. The Contractor shall submit an agenda five working days prior to conference and which shall include:
 - 1 start-up and equipment demonstration/testing schedule,
 - 2 examination of facilities, systems, subsystems and components,
 - 3 problem identification and resolution.

1.04 Submittals

- A. All submittals shall be as specified in Section 01300 and the Contractor shall submit a Start-up Plan for approval not less than 90 calendar days prior to start-up. The Start-up Plan shall provide a schedule for testing and start-up of each component and system with step by step procedures for starting each element of each system. The Contractor is responsible for means, methods, techniques, sequences, procedures, coordination, completeness, accuracy, and validity of the plan. The Contractor may submit individual sections of the start-up plan as they are developed and upon approval, incorporate these individual sections into the overall facility start-up plan. However rejection of individual sections of the start-up plan by the Engineer shall not be considered a cause for delay. The plan shall

identify each person and organization participating in the start-up and identify their duties and responsibilities, and shall provide for contingencies if problems develop during start-up or if a component fails to perform as specified.

- B. The Contractor shall submit the necessary shop drawings showing connections to facilitate start-up and testing, together with written descriptions of how any temporary connection will be used. Separate drawings and descriptions shall be provided for each item or subsystem identified in the start-up plan.
- C. Start up validation procedures shall be submitted giving a complete, step by step description of each test, simulation, and start-up. The start-up schedule shall be submitted by system or subsystem, as appropriate. Process systems are depicted on the contract process and instrumentation drawings. The Contractor shall identify: individuals and organizations involved in the start-up as well as their duties and responsibilities; test equipment required and include accuracy and calibration information; and shall list data requirements and identify proposed methods of demonstrating compliance with specified performance requirements,
- D. A validation report shall be submitted within seven working days of completing start-up and validation testing and shall include test procedures, specified performance requirements, performance data, and data evaluation.

1.05 Start-up Requirements

- A. Prerequisites to start-up are:
 - 1. building enclosures are complete, weather-tight, and all painting has been completed,
 - 2. all system components have been checked by the manufacturer (where required in the specifications) and are certified as "ready to operate",
 - 3. electrical and instrumentation components are connected to the permanent power supply.
 - 4. outdoor or partially protected equipment and system components are accessible, the predicted weather is acceptable.
- B. The Contractor shall design and provide all:
 - 1. process and utility connections to meet the specified design requirements of the component, subsystem, and system to which they are connected,
 - 2. temporary supports and restraints, ensuring that no structural loads are placed on the permanent facility beyond its design capacity,
 - 3. dielectric unions on temporary connections wherever dissimilar metals connect,
 - 4. safety devices on temporary connections wherever they would be required if the connections were permanent.
- C. The Contractor shall:
 - 1. field test each system and all of its components,
 - 2. demonstrate compliance with the performance specified in the individual sections of the technical specifications. This includes operation in all available modes (e.g. manual and automatic),
 - 3. collect operating data for all system components as specified.
- D. The Contractor shall:

- 1 maintain all components through completion of start-up and testing,
- 2 follow manufacturer's recommendations,
- 3 record all maintenance or repairs performed,
- 4 submit records to the Employer with validation report.

Part 2 Products

2.01 Temporary Connections

The Contractor shall provide all materials necessary for temporary connections. Materials shall be adequate for the application and the Engineer shall be the sole judge of suitability.

2.02 Chemicals and Operating Fluids

The Contractor shall provide all necessary chemicals, power, fuels and operating fluids required for duration of start-up and performance testing. Products and items provided for testing and start-up are in addition to those provided under the technical specifications.

2.03 Spare Parts

The Contractor shall provide all maintenance and replacement parts required during start-up and testing. Maintenance and replacement parts used by the contractor are in addition to those required by the technical specifications.

Part 3 Execution

3.01 Component and System Validation

- A. Each component and each system shall be validated using one or more of the methods described below:
 1. field testing to show compliance with the specifications,
 2. simulate actual operation using a method certified as acceptable and valid by both the component manufacturer and the Engineer,
 3. certification by an independent testing laboratory that the component meets the specified industry standard,
 4. where test procedures are specified, substitute procedures will not be accepted without prior written approval from the Engineer.
- B. Validate components prior to system start-up and testing. Component validation shall include but is not necessarily limited to:
 1. operate each component over its full design range,
 2. demonstrate manual and automatic operation of all components,
 3. demonstrate all emergency shut down and safety devices,
 4. demonstrate normal start-up and shut-down procedures,
 5. demonstrate "out of parameter" corrections,
 6. document actions taken and procedures developed which are not covered in the Operation and Maintenance manual. Provide this information as an Appendix to the manuals.

- C. Validate each system to demonstrate that components operate together to produce the specified system performance. Validation shall require the same items as required for the individual components.

3.02 Validation Prerequisites

- A. The following items must be satisfactorily completed before validation may commence:
 - 1. start-up submittals have been accepted,
 - 2. manufacturers have certified component installations wherever required,
 - 3. specified manufacturer's field services have been completed,
 - 4. auxiliary and support systems are operating properly,
 - 5. no safety defects exist,
 - 6. arrangements for waste disposal (both solid and liquid) have been made,
 - 7. all manual and automatic controls are operational,
 - 8. all equipment has been lubricated and serviced, and it is ready for continuous operation.

3.03 Validation Preparation

- A. The Contractor shall implement safeguards and procedures to protect equipment and facilities from damage during start-up and performance testing and shall construct approved temporary connections and test all temporary connections using the same procedures that would be required if the connection were permanent.

3.04 Performance Testing

- A. Where appropriate (e.g. will not cause damage), tests shall be conducted using either raw or potable water.
- B. Components and subsystems shall be tested before testing the complete system.
- C. Each test shall be conducted in accordance with the approved testing procedures, and shall be scheduled and coordinated with the Engineer. The Engineer shall be notified at least 48 hours prior to re-scheduling a test. The Engineer shall observe all tests in their entirety.
- D. The Contractor shall repair or modify components, subsystems, and systems which do not meet specified performance criteria. The cost of repairs or modifications shall be at Contractor's expense and testing shall be repeated until acceptable performance is achieved. A maximum of two re-tests will be allowed (three tests total) unless the Engineer agrees in writing that additional tests are justified. All equipment, which does not meet the specified performance, shall be removed and replaced with equipment which can meet the criteria and all such work, including the cost of the replacement, shall be at the Contractor's expense. Alternatively the Employer may elect to withhold funds from amounts due to the Contractor and/or claim against the Contractor's performance security in lieu of replacing the faulty equipment.
- E. The Contractor shall collect operating data as specified and at the conclusion of start-up and testing shall drain all water and other fluid, as directed by the Engineer; replace or clean all filters; replace operating fluids; and shall perform equipment services recommended by the manufacturer.

3.05 Field Quality Control

- A. Test equipment used for performance validation shall be calibrated immediately prior to testing. Calibration shall be reconfirmed immediately after testing. Re-testing will be required whenever test equipment is out of calibration at the conclusion of validation testing. The Engineer shall be present during calibration validation.

End of Section 01650

Section 01700: Contract Close-out

Part 1 General

1.01 Description

This Section includes:

- 1 Substantial Completion.
- 2 Final Inspection.
- 3 Close-out Procedures.
- 4 Approvals from Public Authorities.
- 5 Final Cleaning.
- 6 Equipment Operating Data.
- 7 Operating and Maintenance Instructions.
- 8 Warranties and Bonds.
- 9 Spare Parts and Maintenance Materials.

1.02 Definitions

- A. Project close-out requirements include general requirements in preparation for final acceptance such as final payment; normal termination of the Contract and similar actions evidencing completion of the Work. Specific requirements for individual units of Work are specified in the technical sections. Time of close-out is directly related to substantial completion and may be a single time period for the entire work. It may also be a series of time periods for individual parts of the Work that have been certified as "Substantially Complete" at different dates.

1.03 Prerequisites for Substantial Completion

- A. The Contractor shall comply with the following:
1. submit last progress payment request complete with associated releases, consents and supporting documents,
 2. submit final manufacturer certifications, guarantees, warranties, and similar documents,
 3. submit clearance certificates and approvals from government authorities as necessary to connect the Works to the permanent power supply,
 4. submit occupancy permits, operating certificates, final inspection and test certificates and similar releases enabling full and unrestricted use of the Works,
 5. submit record drawings, final operation and maintenance manuals, final project photographs, damage or settlement surveys, property surveys, and similar physical items,
 6. make final changeover of locks and deliver keys to the Engineer,
 7. complete start-up, testing of systems, and training of the Employer's operations and maintenance personnel. Submit equipment operating data as well as all test reports and test data required by the Contract,
 8. dismantle and remove temporary facilities and services from the project site. This includes utilities, construction equipment and tools, buildings and facilities, mockups, and similar elements,
 9. complete final cleaning,
 10. repair and restore exposed finishes which have been marred or damaged,

11. submit all spare parts, tools and maintenance equipment,
12. submit an itemized list of all deviations and non-conformances to the contract requirements including the detailed plan to correct each deviation and non-conformance,
13. notify the Engineer that the facility or Works is ready for the substantial completion inspection. Include the itemized list of deviations and non-conformances in the notification letter.

1.04 Prerequisites for Final Inspection

A. The Contractor shall:

1. submit the last progress payment request complete with associated or corrected submittals stating that each item has been measured and corrected, or otherwise resolved for acceptance;
2. submit the Engineer's and Contractor's list of deficiencies from the substantial completion inspection stating how each item has been corrected or otherwise resolved for acceptance;
3. submit final meter readings for all utilities, a measured record of stored fuel and chemicals, and similar data as of the time of final completion;
4. complete listing of all consumable stores and spare parts used by the Contractor to service the electro-mechanical works throughout the maintenance period;
5. complete submittal of record documents;
6. notify the Engineer that the facility or Works is ready for the final inspection including the itemized list of deviations and non-conformances in the notification letter.

1.05 Project Close-out Procedures

- A. The Contractor shall comply with specified and contractual procedures necessary for issuance of the "Certificate of Substantial Completion."
- B. When the Contractor considers work has reached final completion, the following shall be provided:
1. certificate stating that Contract Documents have been reviewed, work has been inspected and is complete and meets the requirements of the Contract Documents.
 2. all submittals required by governing authorities.
 3. a final statement of accounting giving total adjusted contract sum, previous payments, and the sum remaining due.

1.06 Approvals from Public Authorities

The Contractor shall obtain all clearance certificates and approvals required as a prerequisite to connecting the Works to the permanent power supply and shall coordinate with the Engineer to obtain all necessary documents from the Municipality and other relevant authorities regarding final clearances.

1.07 Final Cleaning

- A. Prior to final inspection the Contractor shall clean all interior and exterior surfaces exposed to view but shall avoid disturbing natural weathering of exterior surfaces and shall:
 - 1. remove temporary labels, stains, and foreign substances,
 - 2. polish transparent and glossy surfaces,
 - 3. clean or replace all air and oil filters for mechanical equipment,
 - 4. clean roofs, gutters, downspouts, and drainage systems,
 - 5. remove debris and surface dust from limited access spaces,
 - 6. clean concrete floors in unoccupied spaces broom clean,
 - 7. clean light fixtures and lamps and install light bulbs so they operate at maximum efficiency,
 - 8. clean the plant site,
 - 9. sweep paved areas and rake all other surfaces,
 - 10. remove litter and foreign substances,
 - 11. remove stains, chemical spills, and other foreign deposits.
- B. The Contractor shall comply with safety standards and governing regulations for cleaning operations and shall:
 - 1. not burn waste materials at the site;
 - 2. not bury debris or excess material on the site;
 - 3. not discharge volatile or other harmful or dangerous materials into the drainage or sewerage systems;
 - 4. remove and properly dispose of all waste materials from the site.

1.08 Project Record Documents

- A. Documents shall be stored separately from those used for construction, in a secure, fire resistive location and protected from deterioration and loss. Documents shall be kept current throughout the construction period and work shall not be concealed until "As Built" information has been recorded.
- B. For record drawings (as-builts) the Contractor shall:
 - 1. maintain a blue line or black line set of prints of all Contract Drawings and Shop Drawings;
 - 2. keep drawings clean and undamaged;
 - 3. mark up drawings to show actual installation if that differs from what is shown on the Contract Drawings. Changes shall be marked up using a red erasable pencil showing "as built" conditions fully and accurately;
 - 4. mark up drawings to show new information of importance which was not shown on either the Contract Drawings or the Shop Drawings. Particular attention shall be given to concealed work that will be difficult to measure or record at a later date;
 - 5. note related change order numbers, as applicable, next to the relevant item on the record drawing;
 - 6. submit documents with transmittal letter containing date, project title, Contractor's name and address, itemized list of documents, and the Contractor's signature.

1.09 Equipment Operating Data

- A. The Contractor shall provide operating data for all equipment specified in the specifications and shall:
1. comply with Section 01300 and submit four sets prior to final inspection;
 2. index and present data in a three-ring side binder with durable plastic cover;
 3. present data on A4 size paper;
 4. separate data by process system. Process systems are defined by the process and instrumentation diagrams included with the Contract Drawings.
- B. The operating data identified below shall be provided for each motor operated equipment item in the stated specification divisions. The data shall be obtained with the equipment operating under design conditions and while handling the process fluid or material specified. No readings shall be taken until the equipment has operated as specified for at least one hour.
1. description of material handled;
 2. material or fluid delivery rate;
 3. system operating temperature and pressure;
 4. motor operating speed;
 5. motor current draw under normal operation and under starting conditions;
 6. bearing operating temperatures;
 7. vibration levels for equipment items with specified vibration limits;
 8. noise levels for equipment items with specified noise limits.

1.10 Operating and Maintenance Instructions

The Contractor shall provide Operation and Maintenance Training as specified in Section 01670 and approved Operation and Maintenance Manuals as specified in Section 01730.

1.11 Warranties and Bonds

The Contractor shall provide, in duplicate, notarized copies of all specified guarantees, warranties, and bonds including those required of manufacturers, suppliers and sub-contractors. Documents shall be assembled in a binder with a durable plastic cover and with a table of contents. The start of the Defects Liability period shall be as defined in the Contract.

1.12 Spare Parts and Maintenance Materials

The Contractor shall provide products, spare parts, and maintenance materials as specified in the technical sections of this specification and shall include itemized lists of all items furnished, describing each item and citing the appropriate specification section and paragraph. Each item shall be packaged for long term storage and shall be marked or tagged for easy identification.

Items shall be delivered to the project site. The Contractor shall provide an inventory of items to the Engineer, and obtain a receipt prior to final payment. Complete listings of all consumable stores and spare parts used by the Contractor during the maintenance period shall be provided.

END OF SECTION 01700

Section 02060: Demolition

Part 1 General

1.01 Description

- A. This section includes all demolition required on the Works. Principle items are as follows:
1. Demolition of the existing on-site buildings and structures shown on the plans which includes dismantling, removal, and off-site disposal of all existing facilities complete including steel frames, wood structures, electrical poles, concrete footings, fencing, piping, fittings, concrete foundations and concrete slabs.
 2. Arranging with affected utility providers for removal of equipment owned by them and disconnection, capping or plugging of utility services to those building to be removed.
 3. Obtain all necessary permits, licenses and/ or inspections and pay all fees and/or provide all bonds required for work under this section if required by any governing authority.

1.02 Title To Property

All materials resulting from demolition work, except as indicated or specified herein, shall become the property of the Contractor and shall be removed from the site and disposed of legally. Rubbish, materials and debris shall be removed daily so as to not accumulate on the site.

1.03 Submittals

- A. Procedures proposed for the accomplishment of demolition work shall be submitted for approval by the Engineer. The procedures shall provide for the safe conduct of the work, removal and deposition of materials, protection of property outside the limits of work, coordination with other work in progress, timely disconnection of utility services and provision of a temporary water supply. Methods and equipment to be used as well as the sequence of operations shall be included. The Contractor's Project Manager at the site shall be named and a schedule for completion of the work shall be submitted for approval.
- B. The Contractor shall record with the Employer, the condition of structures and other facilities adjacent to or within the areas of work which are not to be disturbed. Such record shall include the elevations at the top of foundations, location and extent of existing cracks and other damage, and the description of surface conditions that exist prior to the start of work. Any cost to record by video the existing conditions including that of surveying for elevations is to be included in the price for demolition. Submit two copies of the video tape record.

1.04 Condition of Structures

- A. The Employer assumes no responsibility for actual conditions of the buildings and structures to be demolished. No plans exist on any of the existing facilities. Walls, foundations and base dimensions and embedded rebar sizes if any, are not known. The contractor shall carefully examine the site and make all inspections necessary in order to determine the full extent of the work required. The Contractor shall satisfy himself as to the nature and location of the work, conditions of the facilities upon the ground surface and subsurface materials or obstacles to be encountered.
- B. A soil investigation report is available for review at the office of the Employer. The report and related information depict subsurface conditions only at the specific locations and at the particular time designated on the boring logs. Soil conditions and ground water levels at other locations may differ from those occurring at the boring locations.

1.05 Salvage

Items of salvageable value to the Contractor may be removed from the work as it progresses. Salvaged items shall be transported from the site as they are removed. Storage or sale of removed items on site is not permitted.

1.06 Protection

- A. Conduct demolition operations and removal of debris to ensure minimum interference with existing, or Contractor installed temporary water supply, bridges, roads, streets and other adjacent occupied or used facilities including those on-site. Do not close or obstruct public streets without written permission from authorities having jurisdiction. Provide temporary barricades, fences, canopies, railings or other safeguards to eliminate hazards to persons and property without interference to use of adjacent property, public rights-of-way, utilities and structures. Provide any signs or lights deemed necessary by the Engineer.
- B. Prevent the spread of dust and flying particles. Sprinkle rubbish and debris with water to keep dust to a minimum during dry conditions.
- C. Maintain adequate fire protection, including operative water hose lines from the temporary water supply during demolition.

1.07 Safety

- A. The use of explosives is not permitted.
- B. Materials and debris shall not be disposed of by burning at the demolition sites.

Part 2 – Not used

Part 3 – Execution

3.01 General

A After date of Notice to Proceed with work and after temporary water supply facilities have been erected, assume responsibility for buildings, structures and items shown to be demolished and removed, until such work is completed.

B Notices to the effect that demolition is in progress and that structures may be in a dangerous state shall be placed at the site of demolition so that they are clearly visible.

C Perform work by personnel experienced in this type work and in such manner as to eliminate hazards to persons and property without interference with new work and without use of adjacent areas, public rights-of-way, utilities and structures. Shoring and bracing shall be provided as necessary.

D Except as otherwise indicated or directed, salvageable items, rubbish and debris resulting from demolition shall become property of Contractor, be disposed of off-site and will not be allowed to accumulate or be buried on site.

E Coordinate fully with work of other trades, and perform all work in conformance with applicable requirements of the Safety Orders herein specified.

3.02 Utilities

A Issue written notices of planned demolition operations to owners of utilities having on-site facilities.

B Arrange with utility owners and the Employer to remove any equipment owned by them on the property to be demolished. Also request removal, disconnection, capping or plugging of their services to facilitate demolition work. Seal and cap all utilities at the property line, unless otherwise indicated, if not done by the utility owners in accordance with their rules and regulations. Existing water faucets and taps may be left for use during demolition work but shall be removed prior to final completion and the water lines sealed and capped. Water services need not be removed from the site but shall be capped a minimum of 300mm below the surface. Remove completely all electrical poles and wires from the site once disconnected by the power authority and if not removed by them.

C Preserve in operating condition, unless otherwise noted, all active utilities traversing the project site. Repair damage to such utilities caused by demolition work to the satisfaction of the owner of the utility.

3.03 Demolition

A Demolish concrete walls, foundations and slabs in small sections. Continuously wet down debris to prevent creation of dust. Haul all debris or materials promptly from site as they accumulate.

B The existing buildings and structures shown to be removed shall be totally demolished and removed to the depth of the foundation, footings or slabs. Any resulting voids or openings below the existing adjacent finish grade shall be filled to the level of the finish grade to provide surface water drainage with clean uncompacted dirt from the same property and to 95 percent compaction. Prior to placement of fill material, ensure that areas to be filled are free of standing water, trash and debris. Concrete slabs shall be broken up and removed.

3.04 Cleaning roads

Take precautions to maintain cleanliness on roadways and other public areas. Contractor will be held responsible for immediate removal of all spillage.

3.05 Clean-up

Remove from the site all rubbish and debris found thereon and all materials and debris found thereon and all materials and debris resulting from demolition. Leave site in safe and clean condition.

End of Section 02060

Section 02200:Earthworks and Site Preparation

Part 1 General

1.01 Description

Principal work in this Section includes requirements for earthwork including site preparation. The entire area within the limits of earthwork, as indicated, shall be constructed to the lines, grades, elevations, slopes, and cross sections indicated on the Drawings. Slopes shall present a neat uniform appearance upon completion of the work and shall be approved by the Engineer. Excavated materials meeting the requirement of fill materials may be conserved for subsequent use or placed as earth fill immediately after excavation upon approval of the Engineer. If not re-used within one day, the storage in streets for sub-sequent use as back-fill will not be permitted. Large rocks, unacceptable as earth fill material, may be stockpiled for use as riprap, if required in the works, subject to all requirements specified for riprap in the specifications. The Engineer shall determine suitability of all excavation materials for specific purposes. The Contractor shall not waste or otherwise dispose of suitable excavated materials unless otherwise directed by the Engineer. All excavation shall be performed under the limitations and requirements set out in the sections of this specification pertaining to control of water.

1.02 Definitions

A. The following terms shall have the meanings assigned to them:

1. "Topsoil" means any surface materials suitable for use in areas to be grassed or cultivated.
2. "Bulk Excavation" means excavation in open cut in all material of whatever nature encountered (excluding Trench and Structure Excavation) down to levels specified on the Drawings or otherwise as being the general levels after completion of excavation other than Incidental Excavation.
3. "Trench Excavation" means excavation of trenches in all material of whatever nature encountered into which pipes, ducts or cables are to be laid and appurtenances constructed to levels and limits specified on the Drawings or otherwise.
4. "Structure Excavation" means excavation in all material of whatever nature encountered for the construction of pump stations, tanks, structure and building footings and other structures to levels and limits specified on the Drawings or otherwise.
5. "Incidental Excavation" means excavation in all material of whatever nature encountered (generally in small quantities) below or outside the limits of Bulk Excavation, Trench and Structure Excavation, but excluding Excess Excavation.
6. "Excess Excavation" means excavation in all material of whatever nature encountered outside the limit specified for Bulk, Trench, Structure or Incidental Excavation.
7. "Rock Excavation" means excavation of all material, if not fractured and removable by mechanical excavator, with a sonic density of 2500.

1.03 Quality Assurance

Testing of all materials shall be carried out by an approved, independent, laboratory which is fully equipped to carry out site, and laboratory, testing. Details of the proposed laboratory shall be submitted for Engineer's review and approval at least 15 days before commencing earthwork.

1.04 Earthwork

- A. Earthwork shall include all site preparation to the lines, elevations and grades, indicated on the Drawings including the following:
 - 1. excavation of all materials of whatever nature encountered; handling, hauling and compaction of required fill materials; disposal of all excess excavated material;
 - 2. bracing, shoring and protection work;
 - 3. preparation of subgrade;
 - 4. dewatering as necessary;
 - 5. protection of adjacent property;
 - 6. backfill;
 - 7. surface reinstatement;
 - 8. riprap;
 - 9. embankment.

1.05 Site Investigation

- A. The soils investigation report prepared for the project is available for inspection at the office of the Engineer by prior appointment. This report is for information only and without any warranty as to the correctness of the information contained therein. Availability of this report to the Contractor does not relieve him of his obligation to thoroughly investigate for himself the nature of the Site and the sub-soil conditions therein and his obligations and responsibilities under the terms and conditions of the Contract.
- B. The Contractor shall be deemed to have visited the Site prior to submitting his Tender and made all necessary inspections and investigations and shall be deemed to have allowed for these in his Tender including:
 - 1. means of access and working space;
 - 2. clearing and grubbing;
 - 3. nature of the ground and sub-soils;
 - 4. presence of existing buildings, structures and foundations or other hidden obstructions;
 - 5. level of the water table;
 - 6. extent of rock;
 - 7. support to neighboring properties and structures;
 - 8. all factors affecting the work including any information made available to the Contractor, either in these documents or by any other source, will not relieve the Contractor of his responsibility to decide for himself the nature and extent of the Work nor will it guarantee that similar conditions will apply on other parts of the Site. The Contractor shall be deemed to have contacted the relevant statutory

bodies to establish the existence of any existing, live or redundant services adjacent to or passing through the Works and shall be deemed to have allowed in his Tender for their diversion or removal. Boring logs and related information depict subsurface conditions only at the specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at the boring locations. The passage of time may result in a change of the subsurface conditions or water levels at the boring locations. The Employer does not guarantee any statements, opinions, or conclusions contained in the report. The Contractor shall assume all responsibility for deductions and conclusions made by him regarding the nature of the materials to be excavated; the difficulties involved; dewatering; maintaining the required excavations; and carrying out the work affected by the subsurface conditions at the site of the works. Neither the Employer nor the Engineer shall be liable for any loss sustained, indicated by or deduced from said borings, samples, tests, and/or reports, and the actual conditions encountered during progress of the work.

1.06 Levels to be Recorded

Before the surface of any part of the Site is disturbed or the works thereon are begun, the Contractor shall take and record levels of such part, in the manner specified or as agreed with the Engineer. Two working days notice is to be given to the Engineer so that the recording of levels can be performed in the presence of the Engineer.

1.07 Explosives and Blasting

Blasting is not permitted unless authorized by the appropriate authorities.

1.08 Temporary Fencing

Unless otherwise directed by the Engineer, all open excavations and other hazardous areas shall be totally enclosed on all sides by temporary fencing.

In all cases, locations of the temporary fencing proposed by the Contractor shall be submitted to the Engineer for approval prior to installation. The Contractor shall not commence any works until the associated temporary fencing is erected and the installation has been approved by the Engineer.

Damaged sections of temporary fencing shall be repaired or replaced promptly to maintain at all times the standard of fencing and installations as initially approved at no extra cost to the Employer. Temporary fencing shall not be removed from any location without the prior written approval of the Engineer. The name of the Contract and Contractor shall be affixed at regular intervals on these temporary fences.

1.09 Temporary Works

The Contractor shall protect all property and utilities, shall maintain them during the course of the work and shall repair all damage caused by construction activity. The Contractor shall comply with all local rules and regulations for the use of streets.

The Contractor shall include for all temporary works to maintain and protect existing power, lighting, water and telephone services while the Works are being executed. Temporary shutdown of the services shall only be made with the prior approval of the Engineer and the owner of the services. The Contractor shall allow for protecting and maintaining all pipes, culverts, ducts and cables crossed by, or parallel, to his excavations; for keeping all ditches, gullies and channels clear and unobstructed and making good any damage caused to public or private wastewater systems and roads, paths, kerbs and drains and paying all costs and charges incurred.

C The Contractor shall provide protection against rain, wind, storms, or heat to maintain the works, materials, apparatus, and fixtures free from injury or damage. Work likely to be damaged shall be covered at the end of each day's work.

The Contractor shall ensure that all temporary installations are executed in accordance with the requirements of the authorities concerned. All temporary works are to be properly and adequately maintained and on completion of the Contract, or when directed by the Engineer, shall be cleared away by the Contractor. Damage to new, or existing, works that arises as a result of failure by the Contractor to provide proper protection, shall be repaired, or replaced, as directed by the Engineer, at the Contractor's expense.

1.10 Bracing and Shoring

Excavated surfaces shall be supported as necessary to safeguard: work and workmen; to prevent sliding or settling of the adjacent ground; to avoid interruptions in existing services; damage to existing improvements and utilities infrastructure.

The width of the excavation shall be increased, if necessary, to provide space for sheeting, bracing, shoring, and other supporting installations.

The Contractor shall furnish, place and subsequently remove such supporting installations unless ordered otherwise by the Engineer.

Before commencement of excavation for trenches or any structure, the Contractor shall furnish three copies of drawings showing details of the bracing he proposes to use, together with all relevant calculations prepared by a qualified engineer. One copy of the drawings indicating modifications which in the Engineer's opinion are required for the safety of personnel and/or works will be returned to the Contractor.

Where the Contractor proposes to excavate with battered side slopes instead of providing sheeting, shoring, etc., as aforementioned, the Contractor shall furnish three copies of a report by a competent soils engineer, together with all relevant calculations, demonstrating the sufficiency of the proposals. Generally the sloping of trench sides is not permitted.

No excavation work shall commence until the Engineer's consent has been obtained and such consent shall in no way relieve the Contractor from any of his contractual obligations and responsibilities.

1.11 Inspection by the Engineer

When the specified levels of trench or structure excavation are reached, the Engineer shall inspect the ground exposed and If he considers that any part of the ground is by its nature unsuitable, he may direct, the Contractor to excavate further and to refill the further excavation with such materials as he may direct.

Should the bottom of any trench or structure excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the Works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. In this case the cost of the extra excavation and of the additional foundation materials required will be the Contractor's responsibility if necessitated by his negligence.

1.12 Standard Earthwork Compaction Procedure

All compacted earth fill dry density shall equal or exceed the specified percentage as determined by ASTM D1557, Method C. This method will be used to determine the maximum dry density of each type of soil used in compacted fills, backfills, and embankments, and to measure the relative compaction at optimum moisture content of compacted fills, backfills, embankments, and subgrades. Alternatively, method 3.5/3.6 of BS 1377, Part 4 may be used in lieu of ASTM D1557.

During the course of the work, the Contractor, under supervision of the Engineer, will perform such tests as are required by the Engineer, to: identify materials; determine compaction characteristics; determine moisture content; and determine density of fill in place. These tests performed by the Contractor will be used to verify that the fills conform to the requirements of the specifications.

Testing will be performed by qualified staff of the Contractor or an independent testing laboratory approved by the Engineer when, where, and as directed by the Engineer. The costs of all compaction testing and other tests as stated above will be borne by the Contractor. The Contractor shall adjust his operations so as to permit time to make tests and shall excavate and fill such holes as may be required for sampling and testing. Compaction tests shall be made prior to removal of dewatering systems. A subsequent layer shall not be placed until the compaction density of the preceding layer has been approved by the Engineer. The Contractor shall maintain, with copy to the Engineer, a daily log of tests carried out.

1.13 Anti-termite Treatment

Anti-termite treatment shall be carried out through persons, agencies and/or a subcontractor who possess acceptable experience in this field and who can provide references of successful guaranteed work having been carried out earlier.

1.14 Trial Holes

Trial holes shall be excavated well ahead of excavation to such depths as necessary to determine and confirm the alignment for the excavation, soil condition and location of underground utilities and structures. The Contractor shall arrange for the refilling and

reinstatement of trial holes to be carried out immediately after the required information is obtained and reinstatement of trial holes shall be carried out to the approval of the Engineer.

Part 2 - Products

2.01 Borrow Material

A When the quantities of suitable materials obtained from specified excavations are insufficient to construct the specified fills, additional materials shall be obtained from approved borrow areas. The material selected shall meet the approval of the engineer and conform to the following requirements:

TEST	STANDARD	LIMIT
Liquid limit	BS 1377 : Part 2 : Test 4.5	max 25%
Plasticity Index	BS 1377 : Part 2 : Test 5	max 6%
Organic Impurities	BS 1377 : Part 3 : Method 3	max 2%
Acid Soluble Sulphate Content	BS 1377 : Part 3 : Method 5	max 2%
Acid Soluble Chloride Content	BS 1377 : Part 3 : Method 7	max 2%
Compaction Test	BS 1377 : Part 4 : Method 3.5/3.6	
CBR at 95% MDD (soaked)	BS 1377 : Part 4 : Test 7	min 25% for structural fill, min 15% for non-structural fill
In-situ Density Test	BS 1377 : Part 9 : Method 2.1/2.2	

B Borrow pits shall be excavated and finally dressed in a manner to eliminate steep or unstable side slopes or other hazardous or unsightly conditions and to prevent erosion or drainage problems, including ponding of water. The extent and depth of borrow pits within the limits of the designated borrow areas shall be approved by the Engineer. The Contractor shall be responsible for the arrangement and payment for all borrow material.

Any excavated material not required, or not suitable, for use as refilling as aforesaid or use elsewhere in the works is considered as excess material and shall become the property of the Contractor and he shall be entirely responsible for its removal from the Site and for its ultimate disposal.

2.02 Rock for Riprap

Rock for rock riprap shall conform to the following requirements:

1. individual rock fragments shall be dense, sound, and free from cracks, seams and other defects conducive to accelerated weathering. The fragments shall be angular to sub-round in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment.
2. absorption of water shall be not more than 3 percent and the bulk specific gravity (saturated surface-dry) not less than 2.5 as determined by ASTM Method C127 or BS 1377.
3. weight loss in 5 cycles shall be not more than 20 percent when sodium sulfate is used or 25percent when magnesium sulfate is used. The test for soundness shall be performed according to the procedure for ledge rock in ASTM C88.
4. rock that fails to meet the requirements stated above, may be accepted only if similar rock from the same source has been demonstrated to be sound after 5

years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

2.03 Anti-termite Treatment

Solution used shall be a 2 to 4 percent Basement TR solution applied strictly as per manufacturer's instructions and shall be capable of offering a minimum of 20 years warrantee against termite attack. Equal alternative chemical solutions can be proposed by the Contractor for the Engineer's approval.

Part 3 Execution

3.01 Clearing and Grubbing

The Contractor shall clear the Site of all vegetation, rubbish, debris and other objectionable materials. He shall also clear the access routes to the Site and any other areas deemed necessary by the Engineer to facilitate the construction of the Works. When clearing vegetation, the Contractor shall ensure that the roots of the trees, bushes, shrubs, etc. are fully removed. The Contractor shall dispose of all cleared vegetation, rubbish, debris and other objectionable materials in a controlled manner off-site to a location approved by the relevant authorities. The Contractor shall be responsible for the proper upkeep and maintenance of the Site and the Works and shall remove from the Site rubbish and other waste as it accumulates.

B The Contractor shall check with the relevant authorities to determine what existing services are present in the Site area. The Contractor shall locate and effectively seal off drain ends. When necessary, the Contractor shall divert services still in use and provide all temporary works necessary to maintain such services in full functional order. He shall reinstate such services to the approval of the relevant authorities at the earliest opportunity and comply with regulations and obtain necessary permits.

3.02 Protection

Bench marks and other permanent structures in the Site shall be protected from damage or displacement.

3.03 Control of Water

- A. The Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep excavations and borrow areas free from water during construction and shall remove all water so as not to cause damage to private property, or to cause a nuisance or menace to the public all as specified herein. Berms shall be provided to prevent surface water from draining into structural excavations. Earth banks shall be suitably protected from damage by erosion during construction. The Contractor shall ensure that, at all times, during construction no groundwater shall come into contact with any pipeline, concrete surface or reinforcement forming part of the permanent works and that any structure shall be capable of withstanding any hydrostatic pressure to which it may be subjected during construction and until completed.

- B. Drainage ditches, diversions, and temporary pipes shall be constructed as required to maintain drainage of the work areas and shall be constructed with cross-sectional area at least equal to that of the intercepted watercourses, as approved by the Engineer.
- C. The Contractor shall perform dewatering as required so that all work under the Contract is installed on dry areas and excavations, including without limitation the construction of all structures and underground piping. The Contractor shall ensure that dewatering is carried out only to a depth sufficient for the required excavation.
- D. When extensive dewatering is required, and if, in the opinion of the Engineer, the Contractor is not fully qualified to perform the dewatering operations, the Contractor shall furnish the services of an experienced, qualified, and equipped Dewatering Subcontractor to design and operate the dewatering and groundwater recharging systems required for the work, all subject to the Engineer's approval.
- E. Where required to do so by the Engineer, the Contractor shall establish a specified number of groundwater level monitoring stations at each site which will be observed during the work. These shall be located as directed by the Engineer and consist of acceptable open tube piezometers. As directed, settlement gages shall be provided to the approval of, and designated by, the Engineer at each site, times and locations to monitor settlement of new and existing facilities.
- F. Where deemed necessary by the Engineer, shop drawings and data shall be submitted for record purposes only, but not for review or approval showing the intended plan for dewatering and recharging operations. Details of locations and capacities of dewatering wells, well points, pumps, sumps, collection and discharge lines, standby units, water recharge system, water disposal methods, monitoring and settlement measuring equipment, and data collection and dissemination shall be included. These shall be submitted not less than 30 days before start of dewatering operations.
- G. The Contractor shall furnish, install and operate all necessary pumping, well-point dewatering appliances and equipment to keep excavations free from water during construction. He shall dewater and dispose of water so as not to cause injury to public or private property, or to cause a nuisance or a menace to the public. He shall at all times have on hand sufficient pumping equipment and machinery in good working condition for all ordinary emergencies, including power outage. The Contractor shall have available at all times competent workmen for the operation of the pumping equipment. Excavations shall be kept free of water during excavation, construction of chambers, etc; installation of pipelines; placing of structural and trench backfill and placing and setting of concrete. The Contractor shall control surface runoff so as to prevent entry or collection of water in excavations. Static water level shall be drawn down a minimum of 300 mm below the bottom of the excavation to maintain the undisturbed state of the foundation soils and allow the placement of any fill or backfill to the required density.
- H. All required operations shall continuously maintain the level of the water table outside the dewatered areas to prevent damage to structures, pipelines, etc., adjacent to the excavations. A water injection recharging system shall be maintained to replenish the groundwater supply, as required, to maintain the water table, including pumps, piping,

well points, standby units, other required equipment, and a source of water sufficient to meet the recharge requirements. At his expense, the Contractor shall repair and make good all damage, or resettlement, to foundations, or other portion of any existing facilities or structures, damage to existing works caused by permanent or temporary failure or operation of the dewatering or recharging systems, or failure to maintain the existing groundwater level outside the dewatered areas.

- I. Water not injected back into the ground shall be disposed of lawfully without damage to new and existing facilities or adjoining properties.
- J. Release of groundwater to its static level shall be performed to maintain the undisturbed state of the natural foundation soils; prevent disturbance of compacted fill or backfill and prevent flotation or movement of structures, pipelines and sewers. Equipment shall be removed when no longer required, but monitoring and settlement measurement systems shall be maintained in operation until removal is approved by the Engineer. To the extent approved by the Engineer, well-points and like items may be abandoned in place.

3.04 Disposal of Material from Earthworks

- A. Subject to any specific requirements of the Contract, the Contractor shall make his own arrangements for the temporary storage of any excavated material which is required for use in refilling trench or structure excavations, including any necessary double handling. Any permitted temporary material storage alongside the excavation shall be to stable slopes and heights.
- B. Storage in streets of excavated material not to be reused within one day in the backfill of trenches or structures will not be permitted. In this connection the Contractor shall have regard to the working areas available to him for the construction of the Works particularly where this is located in roads or in other places to which the public has free access.
- C. Where the nature of the excavated material is suitable, the Contractor's temporary storage, as aforesaid, shall include for separate storage as the Engineer may direct of any of the various grades of materials hereinafter specified for the refilling and surface reinstatement of trench or structure excavation, namely, soft material, coarse material, hard material and topsoil.
- D. Any excavated material not required for or not suitable for use as refilling as aforesaid or use elsewhere in the works shall become the property of the Contractor who shall be entirely responsible for its removal from the Site and for its ultimate, legal disposal.

3.05 Excess Excavation to be Made Good

- A. At his own expense the Contractor shall remove from the Site all material resulting from excess excavations below that required for the foundation, lining, paving, road base or bedding and shall make good the same with concrete as may be required by the Engineer.

3.06 Anti-termite Treatment Application

- A. Site shall be well drained and cleared of shrubs, tree roots and debris that could provide termite food. Timber used during construction of the foundations, such as pegs, formwork, etc., must be removed. Termite nests if discovered shall be dug up and destroyed. Before constructing foundations for structures, the sides and bottom of excavations and the soil used for backfilling shall be sprayed with an anti-termite chemical solution approved by the Engineer.
- B. Foundations, top course of block masonry at ground floor level - Stage 1. After excavation of the earth for foundations and columns the bottom surface of the trenches shall be sprayed with chemical emulsion at a rate in accordance with the manufacturer's instructions. If the excavations have a rocky base and the surface does not retain the chemical emulsion, the top course of the block walls both externally and internally shall be sprayed soon after the blocks are laid.
- C. Soil under slabs at ground floor level - Stage 2. After earth filling, but before the dry rubble or hard core packing, the entire surface of the filled earth shall be treated with a chemical emulsion at a rate in accordance with the manufacturer's instructions. Light rodding may be necessary to facilitate spraying and absorption.
- D. Junction of walls and floors - Stage 3. Rodding to be carried out along the junction of plinth/basement walls and earth filling at 150 mm intervals with a chemical emulsion sprayed at a rate in accordance with the manufacturer's instructions so as to mix properly with the soil. Both the stages 2 and 3 to be carried out simultaneously to establish the chemical barrier.
- E. Soil along the external wall perimeter - Stage 4. After leveling and before flagging or ground floor protection is laid, soil along the external wall perimeter of the building up to a depth of 30 mm to be treated at a rate in accordance with the manufacturer's instructions. If necessary, rodding at 300 mm intervals may be carried out to facilitate spraying and absorption.
- F. Precautions must be taken not to disturb the treated areas by re-levelling digging or earth filling, as this will break the chemical barrier. In case such a situation arises, area shall be treated again to restore the chemical barrier.

3.07 Placement of Embankment Fill

- A. Embankments shall be placed in a manner such that they meet the following additional requirements:
 - 1. the distribution of materials throughout each layer shall be essentially uniform and the fill shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material.
 - 2. if the surface of any layer becomes too hard and/or smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth not less than 75 mm before the next layer is placed.

3. the top surface of all embankments shall be approximately level during construction except that a crown or cross-slope (super elevation) of not less than 2 percent shall be maintained for effective drainage. If not shown on the drawings, all finish grade embankment top surfaces shall be finished with a 2 percent crown or cross-slope as applicable for the site drainage.
- B. All engineered fills shall be compacted to not less than 95 percent maximum dry density (MDD), including areas to receive future structures, and to a line and grade at least 2 m outside the structure area. All fills shall be moistened or aerated to control the moisture content to within 2 percent of optimum and then compacted. Uniform moisture distribution shall be obtained by disking, blading or other approved methods prior to the compaction of the layer. If the top surface of the preceding layer of compacted fill or foundation becomes too dry or wet to permit suitable bond it shall be scarified and moistened by sprinkling or aerated to an acceptable moisture content prior to the placement of the next layer.

3.08 Testing of Backfill

- A. Tests to determine the optimum dry density of the backfill material shall be carried out as directed, the frequency depending on consistency of material and test results. Unless directed otherwise on site testing for density and moisture content of in situ soils shall be at the rate of:
1. one test per backfill layer for each structure or one test per 500 m², whichever is more stringent,
 2. one test per backfill layer for every 100 linear metres of pipeline trench. except RDA road. For RDA road one test per backfill layer for every 35 linear metres of pipeline trench.

3.09 Foundation Preparation

- A. Foundations for earth fill shall be stripped to remove all obstructions, vegetation, debris, or other unsuitable materials. Except as otherwise specified; foundation surfaces shall be graded to remove surface irregularities and shall be scarified and loosened to a minimum depth of 100 mm. The moisture content shall be controlled as specified for engineered fill and the surface materials of the foundation shall be compacted and bonded with the first layer of earth fill as specified for subsequent layers of earth fill.
- B. All rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed. Rock foundations shall be excavated to 150 mm below finished grade shown on the drawings and a lining shall be placed as specified herein. Fill placed immediately adjacent to such rock foundations or where not accessible with large compaction equipment shall be compacted to the specified density by means of hand tamping or manually directed power tampers or plate vibrators.
- C. Where the slope of existing soils to receive fill exceeds 1 to 4, horizontal benches shall be cut to key the new fill material to the existing soils. At least 600 mm of existing soil normal to the original slope shall be removed and re-compacted as the new fill is brought up in layers.

3.10 Rock Riprap

- A. This work shall consist of the construction of rock riprap blankets for purposes of embankment protection from erosion. The subgrade surfaces on which the riprap is to be placed shall be cut or filled and graded and compacted to the lines and grades shown on the Drawings. The cross sections shown on the Drawings are the limits for cuts and engineered earth fills. Gravel bedding where specified or shown on the Drawings shall be placed on top of cut or filled surface. Gradation of bedding material shall be as shown on the Drawings. Bottom of the riprap bed shall be taken as top of the gravel bedding. Where no gravel bedding is shown or specified, it shall be taken as the embankment surface line shown in the cross-sections. Riprap shall not be placed until the foundation preparation is completed and the finished engineered fill surfaces have been inspected and approved by the Engineer.
- B. Rock shall be placed by equipment on the surfaces and to the depths specified. The riprap shall be constructed to the full course thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock shall be delivered and placed in a manner that will ensure that the riprap, in place, shall be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact one to another with smaller rocks and spalls filling the voids between the larger rocks. Riprap shall be placed in a manner to prevent damage to structures.
- C. Hand placing will be required to the extent necessary to prevent damage to the permanent works. Rock shall be placed by hand on the surfaces and to the depths specified and in accordance with the above Specification. Smaller rocks shall not be grouped as a substitute for larger rock.
- D. Riprap placed in ditches, channels, or alongside structures for erosion protection shall be about 150 mm nominal diameter, while riprap placed on embankments shall range from 150 to 350 mm. All riprap layers unless otherwise specified shall be a minimum of 375 mm in depth. The finished grade shall be reasonably homogeneous in appearance and depth and be free from molds, dips, or windows.
- E. All suitable rock obtained during job site excavation may be conserved for riprap and additional rock shall be obtained from sites to be located by the Contractor and approved by the Engineer. Quarries approved by the Engineer shall not relieve the burden upon the Contractor of ensuring that all rock utilized meets all requirements specified herein.
- F. All riprap designated as slush grouted shall be grouted with grade 20 concrete using 20 mm aggregate. Slush grout concrete shall be placed to fill all voids in the riprap blanket to a minimum depth of 100 mm into the blanket. The grout shall be placed, consolidated and finished with a shovel or it may be broom finished. Slush grout concrete exposed to air after placing shall be sprayed with an approved curing compound, or shall be cured in a manner approved by the Engineer.

3.11 Completion

- A. Upon final completion of the Works, the Contractor shall clear away and remove from the site all remaining constructional plant, surplus materials, rubbish, and temporary

works of every kind and leave the whole of the site clean to the satisfaction of the Engineer. The Contractor shall obtain any local authority clearance permits required.

End of Section 02200

Section 02221: Trench Excavation and Backfill

Part 1 General

1.01 Description

A. Principal work in this section includes:

1. trench excavation, granular pipe bedding, concrete protection of pipe, backfill, compaction and temporary reinstatement .
2. provision of new protection ducts of split Poly Ethylene (PE) pipes, concrete encased, to protect existing utility mains or cables where excavations cross such utility mains or cables.
3. non-disruptive pipeline installation.

1.02 Definitions

"Trench excavation" is as defined in Section 02200.

"Pipe" means pipe or pipes, bends, fittings, junctions, other specials and includes joints, gaskets, flanges, nuts, bolts, washers and lubricants.

1.03 Non-disruptive Pipeline Installation

- A. The Contractor or Subcontractor, which will perform the Work, shall be experienced in the performance of boring and jacking work under similar conditions. The work shall be undertaken from within a shield equipped with steering jacks for adjusting the alignment and face Boards shall be provided for boarding up the exposed excavation.
- B. The Contractor shall monitor line and grade with a laser beam or other suitable equipment as approved by the Engineer. Extreme care shall be exercised to maintain line and grade during jacking operations. Modifications in the manner in which the jacking operation is being conducted may be required to correct any deviation when deemed necessary by the Engineer. The Engineer shall have access to the jacking pit and such use of Contractor's facilities as are necessary to monitor and verify accuracy of conductor pipe line and grade. A maximum tolerance in the line and grade combined of 200 mm in 100 m shall be required. Monitoring of line and grade shall be carried out every 8 m of conductor pipe installed with a minimum of once daily during jacking operations.
- C. Unless otherwise specified, the methods and equipment used in jacking the conductor pipe shall at the option of the Contractor, provided that the proposed method is approved. Such approval, however, shall in no way relieve the Contractor of the responsibility for making a satisfactory installation meeting the criteria set forth herein. It shall be understood that, when a change in construction method or an increase in jacking limits as specified herein or shown on the Drawings is requested by the Contractor, and authorized by the Engineer, no additional payments will be made. Once the jacking operation has commenced, it shall be continued in an expeditious manner until the conductor pipe has been jacked between the specified limits.

Part 2 Products

2.01 Pipe Bedding Material

- A. Granular bedding shall be free draining, hard, clean, chemically stable gravel or crushed stone to BS 882, graded in accordance with BS 882 as follows:

Sieve Size	% Weight of Passing	
(mm)	For Pipes of Dia 400 mm and above	For Pipes of Dia 300 mm and below
37.5	-	-
20	100	-
14	85 - 100	100
10	0 - 50	85 - 100
5	0 - 10	0 - 25
2.36		0 - 25

1. total acid soluble content of the material when tested in accordance with BS 1377 shall not exceed 0.3 percent by weight of sulphate expressed as SO₃.
2. for uPVC pipes only rounded aggregates will be permitted but for all other pipe materials crushed aggregates may also be used.

- B. Concrete bedding or surround shall be Grade 20 in accordance with Section 03300.

2.02 Selected Fill Material

Selected fill material for pipes, to a minimum of 300 mm above the top of the pipe, shall be suitable material selected from the excavated material. Suitable material shall be free from stones greater than 4 mm in size for pipes without coatings and 25 mm for pipes with coatings. The material shall have a liquid limit not more than 25 percent and a plasticity index of not more than 6 percent.

2.03 Remaining Trench Backfill

The remainder of the trench fill material shall be selected from the excavated material and be as specified in Section 02200 for borrow material, provided, in the opinion of the Engineer, the required densities can be achieved.

2.04 Service Protection Ducts

Protection ducts shall be split, unplasticized polyvinylchloride (uPVC) pipe extruded from 100 percent virgin materials and 150 mm diameter unless otherwise approved by the Engineer. All pipes and fittings shall be new and unused. The pipes shall be homogenous and free from visible cracks, holes, foreign materials, blisters, deleterious materials, wrinkles, and dents. Plastic pipe shall be delivered to the site in unbroken bundles or rolls, packaged in such a manner as to provide adequate protection of pipe and pipe ends, either threaded or plain, from damage or exposure to sunlight. All plastic pipe fittings to be installed to PVC pipe shall be molded fittings manufactured of the same material as the pipe and shall be suitable for solvent weld. No site made bends or fittings will be permitted.

2.05 Conductor or Casing Pipe

- A. Pipe to be placed by jacking methods shall be of sufficient thickness and axial strength to withstand the forces to be encountered during the jacking process. The diameter of the jacking pipe shall be the transmission pipe outside diameter plus 450 mm or the socket diameter plus 150 mm, whichever is greater as a minimum.
- B. It shall be the Contractor's responsibility to provide stress transfer, which is capable of resisting the jacking forces, involved across the conductor pipe joints.
- C. All pipes installed in jacked conductor pipe shall have socket and spigot with rubber gasket or mechanical compression joints, except where restrained joint pipe is required. Skids for supporting the transmission pipe inside the conductor pipe and blocking, shall be a hardwood adequate to withstand high bearing stresses and treated by painting with pentachloro-phenol.

Part 3 Execution

3.01 General

- A. The line, level, grade, elevation, slope and cross-section of trenches shall be as shown on the Drawings, specified or as may be directed by the Engineer. Before commencing trench excavation, the route of the trench shall be surveyed and marked in the field by the Contractor accurately and the natural ground levels shall be agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the level to which the excavation is to be carried out and rails shall be not more than 20 m apart. Alternate methods to maintain line and level of pipelines shall be to the approval of the Engineer. The Contractor shall protect and maintain the sight rails until backfill is placed.
- B. Trench excavation shall be carried out by such methods and to such lines, dimension and depths as shall allow for the proper construction of the works, provided always that, unless the Engineer permits otherwise, no trench excavation shall be less than 600 mm in width. Notwithstanding the foregoing, any rock in trench excavation shall be so excavated that the clearance between the pipe, when laid, and the rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding and/or concrete protection of the pipe.
- C. Excavation shall be carried out by mechanical methods except where required to ensure the stability of utilities or structures encountered during excavation work. Excavation at these locations shall be by hand (manual) methods.
- D. The bottom of the trenches shall be properly trimmed off and a compacted granular bed of thickness as shown on the Drawings shall be placed and prepared to provide a firm and uniform bearing throughout the length of the pipe. The bedding shall be lightly raked prior to placing the pipes on it. Holes and depressions for couplings, fittings and the like shall be excavated the same distance below these installations.

- E. Materials excavated shall be used in the backfill or removed and disposed of by the Contractor to an approved location, as required by the Engineer and as specified. The trench shall be dug only so far in advance of pipe laying as the Engineer shall permit. No length of trench excavation shall be started until the pipes and fittings to be laid in that length are available on the Site. Trenches shall have vertical sides unless otherwise authorized by the Engineer.
- F. If obstructions not shown on the drawings are encountered during the progress of the work and these will require alterations to the drawings, the Engineer shall change the plans and order the necessary deviation from the line and/or grade. The Contractor shall not make any deviation from the specified line and/or grade without approval by the Engineer. Should any deviations in line and/or grade be permitted by the Engineer for convenience to the Contractor, any additional costs for the trench work and thrust blocks, valves, air and vacuum assemblies, washout assemblies, extra pipe length, valve chambers, manholes or other appurtenances shall be borne by the Contractor. A sufficient number of air release and vacuum installations and wash out assemblies have been shown on the Drawings at high and low points, respectively. Should the pipeline be constructed in a manner that the points are not located at the stations shown on the plans or in a manner that additional high or low points are caused in the profile for the convenience of the Contractor, the Contractor shall relocate or add additional installations and assemblies at his own expense and as directed by the Engineer.
- G. Unless otherwise specified or instructed, the minimum trench width shall be as required to meet the design requirements and for the proper assembly and joint inspection. To meet design requirements and to minimize disruption of traffic, disturbance of other services or installations and risk to adjacent buildings or structures and where the trench width is not specified elsewhere or shown on the Drawings or where the Engineer gives instructions concerning trench widths, the following trench widths shall normally apply:
1. for rigid Pipes (RC, VC etc.) the maximum width at 300 mm above crown of pipe shall be the outside pipe diameter plus 600 mm. The maximum width for 100 mm and 150 mm pipes shall be 600 mm. If these maximum widths are exceeded, the Contractor shall, at his own expense, provide concrete surround to the full trench width as directed by the Engineer,
 2. for ductile iron pipes, the maximum trench width at 300 mm above top of pipe shall be the outside pipe diameter plus 600 mm except for 100 and 150 mm pipes where the maximum trench width shall be 600 mm. If this maximum width is exceeded, the Contractor shall, at his own expense, provide concrete surround to the full trench width as directed by the Engineer,
 3. for flexible pipes (PE GRP, HDPE etc.) the minimum trench widths for these pipelines depend on the deformation modulus of the bedding material (EB) and of the native soil (ES) at the springing or axis level of the pipe. The deformation modulus of the native soil (ES) at axis level of the pipe is variable depending on the location of the pipe. The deformation modulus of the bedding material shall be as recommended by the pipe manufacturers. Before, and as the work proceeds, both deformation moduli shall be determined by static cone penetrometer tests. To determine EB a short length of trench shall be excavated, filled with bedding material, compacted and tested at the start of the Contract. If, in the Engineer's opinion, the EB value is satisfactory, normal compaction procedures for granular bedding and surround shall be adopted. If the EB value

is unsatisfactory, the Engineer will issue instructions for either a change in the bedding material or additional compaction procedures, at no extra cost to the Contract. To determine ES, static cone penetrometer tests shall be carried out in trial holes at formation level at intervals along the pipe line to be determined at site which, in variable ground conditions, may be for every pipe length. The costs of cone penetrometer tests shall be included in the rates for pipeline construction. When the values of EB and ES have been determined, the Engineer will determine the minimum width of excavation necessary for a particular location. This minimum width may vary from three to a maximum of five times the nominal outside diameter, depending on the ES value. If, due to space limitations or other practical considerations, the minimum trench widths cannot be attained, or as shown on the Drawings, the Engineer will direct the Contractor to adopt either: Using a pipe of higher stiffness value; changing the bedding to concrete bed and surround or leave in the trench sheeting.

3.02 Supporting Trench Excavations

- A. Contractor shall well, and effectively, support the sides of all trench excavation in accordance with the submittals required by Section 02220. Support shall include the use of steel sheet piles, where necessary, to prevent any fall or run from any portion of the ground outside the excavation into the trench and to prevent settlement of, or damage, to structures adjacent to the excavation.
- B. When concrete encasement of pipeline, or granular or selected fill is required in pipe trenches the supporting installation shall be designed to permit gradual withdrawal during the placing of the encasement or fill. This shall be affected in such manner as to minimize the danger of collapse and all voids formed behind the supports shall be carefully filled and compacted.
- C. The Contractor shall be deemed to have made his own allowance for shoring up the sides of trenches and any extra excavation necessary to provide space for such support and for any other working space.
- D. If, for any, reason any portion of trench excavation shall give way, the Contractor shall, at his own expense, take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed.
- E. Where the Contractor elects and is permitted by the Engineer to execute trench excavations with battered sides instead of providing support as aforesaid they shall be excavated to stable slopes and heights from a point of 300 mm above the top of the pipe. Drawings and data shall be provided in accordance with Section 02220.

3.03 Trimming Trench Excavation

- A. When excavating to specified levels for trench excavation, or to specified limits for the face of any structure or thrust block therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing construction work except where the Engineer permits otherwise. Should the Contractor have excavated to within 150 mm above these specified levels, or to within 150 mm of

these specified limits, before he is ready, or able, to commence the construction work he shall, where required by the Engineer, excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work. Any such further excavation and additional foundation material ordered by the Engineer shall be at the cost of the Contractor. Where no bedding material is specified, the bottom of trench excavations shall be carefully boned in and trimmed true to grade with the aid of a straight-edge at least 6 m long so as to ensure a continuous support for the pipes. Any stones or flints, greater than 25 mm in size, likely to cause the pipe to bed unevenly or to damage the pipe and its coating shall be picked out of the trench bottom. Any holes so formed shall be filled in with soft material and trimmed to the correct level. Where bedding material is specified, all shattered and loose material shall be removed from the bottom of the trench excavations so that the bedding material rests on a solid and clean foundation.

3.04 Pipe Bedding

- A. After trimming, granular bedding material shall be spread in the trench bottom. If, through the Contractor's neglect, any trench bottom is excavated below the grade shown on the plans, it shall be refilled to grade of pipe invert with bedding material, thoroughly compacted into place, or concrete at the Contractor's expense and at the Engineer's discretion. Concrete barriers shall be formed in granular bedding and/or surround to pipes to prevent the bedding acting as a sub-soil drain. Barriers shall be provided at a maximum spacing of 100 m with one at each manhole or valve chamber and at least one barrier between two adjacent structures. Concrete barriers shall be of Grade 20 concrete, and shall be installed across the full cross-section of the granular bedding material and shall be at least 300 mm in thickness along the axis of the pipeline.
- B. Where indicated on the Drawings, or ordered by the Engineer, pipe shall be encased, haunched and/or backfilled with concrete in accordance with the details shown on the drawings. Concrete shall not be placed until the joints at each end of the pipe have been completed. Each pipe to be encased or haunched shall be supported on at least two purpose made precast concrete blocks, which shall be left in place. Concrete encasement shall be placed to the required depth in one operation. Pipe shall be prevented from floating or otherwise moving during concreting. Except where shown otherwise or ordered by the Engineer, the continuity of concrete backfill or encasement to pipe with flexible joints shall be broken at each joint. Flexible joints in concrete beds and surrounds to pipes shall be formed as shown on the Drawings with suitable compressible fibrous board or other similar approved material.
- C. Where soil is completely unstable, and if, in the opinion of the Engineer, large settlements in the pipe line are expected, special arrangements are to be made after proper site investigation and structural calculations. These special arrangements shall be: improvement of mechanical properties of the soil; replacement of soil by other soil or concrete; addition of crushed rock; pile foundations or R.C. slab foundation. Where such conditions occur, a report shall be submitted to Engineer, or his representative along with all the site data and contractor's proposal for approval. Where hard rock occurs in the bed just before or after compressible soft bed, the Contractor shall provide a flexible joint at the junction of two materials to allow rotation of pipe pieces without damage in case of settlement of soft bed. In the case of pipelines laid under the slope of an

embankment, any longitudinal tensile or bending stress occurring in the pipe shall be taken into account.

3.05 Trenches not to be Left Open

- A. The Contractor will not be permitted to excavate trenches in more than one location in any one road at a given time without the Engineer's permission. Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed. Pipe laying shall follow closely upon the progress of trench excavation. The Contractor shall not permit unreasonably excessive lengths of trench excavation to remain open while awaiting testing of the pipeline but not more than 30 m ahead of the pipe laying operation or greater lengths if approved by the Engineer. Excess trench lengths in which pipe cannot be installed during the approved working period(s) shall be backfilled and re-excavated during the next work period, all at the cost of the Contractor.
- B. The Contractor shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded and these precautions may include the partial refilling of the trench leaving pipe joints exposed for tests of the joints.
- C. If the Engineer considers that the Contractor is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation.

3.06 Control of Water

- A. All excavation and placement of bedding and backfill shall be carried out in the dry as described in Section 02200.

3.07 Trench Excavation in Roads

- A. Where open cut excavation is used as a construction method, all trench excavation and other work carried out within the limits of any existing road or highway shall be completed as rapidly as possible and not more than half of the width of the carriage way shall be obstructed at any one time. This may require hauling away excavated material and returning as backfill as required. The Contractor shall program his work in such a manner that the minimum inconvenience is caused to those persons using the road.
- B. If, in the opinion of the Engineer, the amount of traffic using a road which is completely or partly obstructed by the works is sufficiently great to make it necessary, the Contractor shall operate a system of traffic control to the approval of the Engineer and the traffic police. Any such system of control shall require appropriate large letter warning signs at the approaches (1, 0.5 and 0.25 km) to sections of road in which, or adjacent to, which work is being executed. These signs shall be removed immediately the dangers of which they provide a warning have been removed. If the Contractor wishes to stop traffic completely for any significant period of time, he shall submit a plan in advance for the approval of the Engineer and traffic police for permission to do so. Obstruction of the road shall not begin until the Contractor receives the Engineer's

permission in writing. Such permission will not, in general, be granted for roads which have more than two traffic lanes or for those sections of roads for which satisfactory alternative routes do not exist. Appropriate lighting shall be provided for protection of the Works and road users during periods of darkness. Costs incurred by the Contractor in respect of all aspects of work in roads including maintaining access past the works, the provision of a traffic control system and warning signs and the like shall be included in the rates for excavation and pipe laying. The Employer will not be liable to pay any compensation to the Contractor for traffic control. Or in any reason, such permission as to close any road to traffic should not be granted to the Contractor.

- C. Where trenches are open cut in asphalt or concrete roads, the roads shall be saw cut 200 mm back from the edge and along the edges of the trench, prior to excavation.
- D. Road drains and channels shall be kept free from obstruction at all times and flows therein diverted away from pipe trenches.
- E. Normally trench excavation along roads will be located in the service reserves or verges adjacent to the road rather than in the carriageway itself. Trench excavation shall wherever practicable, be carried out in such a way that the excavation is at least 1 m clear of the existing edge of the carriageway. In such event, the Contractor shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when excavation is begun until the refilling of the trench is placed, to ensure that there is no disturbance of the adjacent road construction or foundation.
- F. The Engineer may direct the trench excavation to be realigned from that shown on the Drawings in order to avoid interference with existing utilities and structures or to facilitate smooth traffic flow.
- G. Where trench excavation, or any other part of the Works, obstructs any footpath or right-of-way, the Contractor shall provide, at his own cost, a temporary footpath around the obstruction to the satisfaction of the Engineer to maintain access at all times. Where applicable, this temporary footpath shall include stout bridges of wooden planks with handrails or other approved construction methods across any open trenches.

3.08 Trench Excavation in Surfaces Other than Roads

Trench excavation in surfaces other than roads shall include all surfaces except those asphalt surfaces which require road reinstatement. These surfaces include, but are not limited to, cultivated areas, undeveloped areas, footpaths, verges, non-asphalted roads, lanes, alleys, and all private lands. Trench excavation shall, if the Engineer so requires, have temporary fencing erected around that length, at no extra cost to the Employer. Temporary fencing shall not be removed without the Engineer's permission, which will not normally be given until the trench excavation has been refilled, compacted and reinstated. The Contractor shall have particular regard to the safety of animals which may encroach upon the areas, and shall ensure that all open excavation, access routes and steep or loose slopes arising from the Contractor's operations are adequately fenced and protected.

3.09 Installation of Service Protection Ducts

After the split PE pipe has been placed around the existing utility mains or cables to a minimum length of pipe trench excavation width plus 300 mm on each side, the pipe shall be wrapped twice with polyethylene film, 150 microns thick, to prevent fresh concrete from entering the duct. Protection ducts shall be supported on suitable non-corrosive spacers before placing concrete encasement around the duct. All concrete work shall be in accordance with Section 03300 and concrete encasement shall be with Grade 20 concrete.

3.10 Backfilling Trench Excavation

- A. Selected fill material for pipe surround shall be deposited in layers of not greater than 150 mm compacted thickness and thoroughly rammed with suitably shaped rammers working alternately on either side of the pipe (particular care being taken to avoid damage to the pipe and any sheathing) until the select fill has been carried up at least 300 mm above the top of the pipe.
- B. The remainder of the trench fill material shall be spread in layers of not greater than 150 mm compacted thickness and shall be thoroughly rammed by an approved mechanical rammer. Depths greater than 150 mm shall be allowed, provided it is demonstrated that the compaction equipment can achieve the required density through the depth of the backfill layer. Backfilling is to be carried up to the level at which (in roads and footpaths) surface reinstatement or temporary pavement is to commence or (elsewhere) to such level as with the surface reinstatement of the whole of the topsoil will leave the finished work sufficiently "proud" to allow for future settlement to the original ground level.
- C. Where necessary, the Contractor shall adjust the moisture content of the refill material either drying out or by adding water to assist the compaction of the material. During compaction, the backfill shall have a uniform moisture content to within 2 percent of optimum moisture content recorded in the Compaction Test. Backfill shall be compacted to a dry density of not less than 90 percent maximum dry density (MDD) in landscaped, open areas and areas outside of road reserves and 95 percent MDD elsewhere except RDA roads where not is required, when tested in accordance with these specifications.
- D. Should the material being placed as backfilling, while acceptable at the time when approved, become unacceptable to the Engineer due to exposure to weather condition, or due to flooding, or have become puddled, soft or segregated during the progress of works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.
- E. To permit the proper consolidation of backfill into the voids behind trench sheeting and supports, trench sheeting shall be withdrawn gradually as backfill progresses in depth and along the trench. On no account shall any excavated material be pushed back into the trench when refilling trenches in roads. No backfilling shall be carried out unless in the opinion of the Engineer, sufficient mechanical rammers are in operation on that portion of the work.
- F. Where directed by the Engineer, trench excavation shall be refilled with concrete.
- G. Where, in the opinion of the Engineer, sufficient supplies of the aforesaid material for trench refilling cannot reasonably be obtained from excavations the Engineer may order

the Contractor to carry out such work as may be necessary to sieve out stones, or excavate material from suitable borrow areas and transport it to the length of trench to be refilled. The Contractor shall do any or all of these things as directed and all costs for borrow material shall be borne by the Contractor.

3.11 Pipeline Identification

All lines unless otherwise specifically indicated on the drawings shall be marked with a high quality acid and alkali resistant coloured polyethylene tape with a minimum width of 300 mm placed, during backfilling, 300 mm above crown of the pipe, or as directed by the Engineer. The tape shall be clearly marked in black lettering as appropriate with a maximum longitudinal spacing of 1 m.

3.12 Surface Reinstatement in Asphalt Paved Roads

- A. Temporary reinstatement shall be provided immediately after backfilling and compacting the trench and compacted as specified to enable the road to be used for vehicular traffic. Temporary reinstatement shall be one of the following alternatives:
 - 1. Deleted
 - 2. After scarifying and trimming the broken edges of the existing surface, a base of ABC graded from 3 mm to 75 mm shall be spread over the area to be reinstated. The thickness of the layer shall be such as to provide a consolidated thickness of 500 mm when well compacted by a power driven 4000 kg roller. Prime coat of CSS-1 shall then be applied at a rate of 1 litre per 1 sq.metres with sand sealing using CSS-1 at the rate of 11t/sq.m. The surface shall finally be rolled with an 4000 kg power driven roller to provide a surface that matches the level of the existing paved surface.
 - 3. As required by the concerned authority
 - 4. In case of delay of more than one month in carrying out permanent reinstatement cold mix layer of compacted thickness shall be placed on the temporary reinstatement done as above.
- B. Any road markings damaged or destroyed by the work shall be replaced on the temporary surface to the satisfaction of the local authority.
- C. Permanent Reinstatement shall be as specified in the Particular Specifications.

3.13 Reinstatement of Surfaces Other Than Asphalt Paved Roads

Road reinstatement shall be done as stated in the drawing Nos. Ha.Hoarafushi /STD/01 & Ha.Hoarafushi /STD/02

3.14 Appurtenant Structures in the Pipeline

The Contractor shall carry out further excavation as may be necessary to accommodate structures such as manholes and valve chambers and such excavation shall include for disposal of surplus material and, where appropriate, for backfilling around the structures.

3.15 Fill Adjacent to Structures

No fill materials shall be placed, and no compaction shall be permitted, adjacent to concrete for a minimum of fourteen days following placing of the concrete. Fill materials adjacent to structures shall be placed in such a manner as will ensure that they can be satisfactorily compacted without damage to the structures. Compaction adjacent to structures shall be carried out by hand or by suitable hand operated plant as soon as the fourteen day period has ended.

3.16 Existing Services

- A. Notwithstanding any relevant information furnished by the Employer or Engineer, the Contractor shall be responsible for ascertaining, from his own inspection of the Site and the respective utility authorities and other public bodies, the position of all mains, pipes and cables whether underground or overhead, within or near the Site.
- B. Where trench excavation is carried out close to, or across, the line of sewers, pipes, cables and other services, the Contractor shall, where necessary, provide temporary supports or slings. Where such sewer, pipe, cable or other service is temporarily disturbed it shall be replaced.
- C. Where specified on the Drawings, or by the relevant Utility Authority, split ducts shall be provided as specified in paragraph 3.09.
- D. Where, in the opinion of the Engineer, construction of the pipeline cannot reasonably be carried out unless the sewer, pipe or other major service is permanently severed, permanently diverted or permanently supported by concrete, he shall order the Contractor to undertake such work (metered water service connections are not included under this). Any relocation of existing services shall be done in accordance with the requirements of the responsible authorities. The repair or replacement of existing water service connections shall be considered as part of the Contractor's work and included in the rates.

3.17 Fences and Walls

Where trench excavation crosses surface barriers such fences and walls the Contractor, as a temporary measure during construction of the pipeline, shall provide temporary fencing for any parts of such barriers that have to be removed. After trench excavation has been reinstated, the Contractor shall carry out such work as the Engineer may order for permanent restoration of such barriers.

3.18 Crossing Watercourses

The Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the pipeline where it crosses under or over streams, culverts and other watercourses, including maintaining the full flow of water in the watercourses.

3.19 Nuisance from Noise and Dust

- A. The Contractor shall take all precautions which, in the opinion of the Engineer, are necessary to minimize nuisance arising from noise and dust when working in the vicinity of residences, schools, hospitals, clinics, religious areas and offices. All engine-driven machines shall be fitted with efficient silencers which are not necessarily those supplied by the manufacturers of the engines or plant and if necessary, plant shall be screened with acoustic materials. If, in the opinion of the Engineer, it is unreasonable or undesirable for pumps, or concrete mixers to be driven by combustion engines, the Contractor shall, when so required, provide electric motors to operate the plant. Driver shall minimize the use of horns.
- B. Compressed air operated equipment, tools, and ventilation equipment shall be effectively muffled or shall be of a design having a low noise frequency.
- C. The Contractor shall utilize submersible pumping plant which is electrically powered so as to avoid any nuisance or disturbance to the general public. The pumping plant may be supplied with power from a diesel engine generator which shall be acoustically insulated so that the emitted noise level shall not exceed 65 dBA measured at a distance of 3 m from the equipment. The noise level near houses, and sound insulation procedures to keep the noise nuisance to the minimum, shall be approved by the Engineer.
- D. The Contractor shall keep all streets affected by construction, or by construction equipment, free from dust and excavated material. Streets shall be washed or swept daily, or as otherwise required by the Engineer.

3.20 Non-disruptive Pipeline Installation

- A. The leading section of conductor pipe shall be equipped with a jacking head securely anchored thereto to prevent any swaying or variation in alignment during the jacking operation. Excavation shall be performed entirely within the jacking head and no excavation in advance thereof shall be permitted. Every effort shall be made to avoid any loss of earth outside the jacking head.
- B. Excavation shall be kept to a minimum, but shall be of sufficient dimensions for satisfactory completion of the work. If so required, bracing and shoring, steel sheet piles or such other material as may be approved by the Engineer shall be provided to adequately protect the workmen and to protect the surface finish at no extra cost to the Employer.
- C. Excavated material shall be removed immediately and continuously from the conductor pipe as excavation progresses. The method of removal will be at Contractor's selection and no accumulation of excavated material within the conductor pipe shall be permitted.
- D. Ventilation shall be furnished in the conductor pipe and at the working face as necessary to protect the men and meet safety requirements.
- E. After jacking is completed; the Contractor shall tap the conductor pipe with a hammer to locate ground loss or other voids outside the pipe. Holes shall be drilled in the conductor pipe at suspected locations and ground shall be forced in to fill voids to refusal at pressures determined by the Engineer, but not to exceed 396 kPa. Should appreciable

loss of ground occur during the jacking operation, the voids shall be backpacked promptly to the extent practicable with soil cement consisting of a slightly moistened mixture of one part cement to five parts granular material. The cement mixture shall be thoroughly mixed and rammed into place as soon as possible after the loss of ground.

- F. After grouting, the conductor pipe shall be cleaned and the transmission pipe installed. The transmission pipe shall be supported on concrete blocks and timber wedge with a bearing area of one quarter of the transmission pipe circumference with of sufficient thickness to prevent the pipe sockets from touching the conductor pipe and to align the pipe to meet the line and level specified.
- G. Concrete shall then be placed to provide a minimum concrete bedding to half pipe height and care shall be taken to ensure the transmission pipe does not move. After the concrete cradle is set the remaining annulus shall be filled with concrete to within 150 mm of the soffit of the conductor pipe. The voids will then be pressure grouted to refusal. All concrete bedding, filling and grouting shall be carried out between shutters and the whole annulus shall be filled completely with concrete for the whole length between shafts.
- H. If other pipe boring methods are to be used they shall be approved by the Engineer.

3.21 Clean-up

Upon completion of work of this section, all rubbish, debris, and excess or waste material shall be removed from the Site. All construction tools, equipment and items left from construction shall be removed and the entire area involved shall be left in a neat, clean and acceptable condition. Any road markings damaged or destroyed by the work shall be replaced to the satisfaction of the concerned authority.

End of Section 02221

Section 02222: Structure Excavation and Backfill

Part 1 General

1.01 Description

Principal work in this Section includes:

- 1 Excavation for Structures
- 2 Structural backfilling

1.02 Requirements

Definitions of terms are as defined in Section 02200.

- A. The line and level of structural excavations shall be as shown on the drawings or as may be directed by the Engineer. Before commencing excavation, the structure shall be staked out accurately and natural ground levels shall be agreed with the Engineer. Excavations shall be of sufficient size to permit the placing of structures or structure footings of the full width and length indicated. Where any sloped excavations infringes on, or potentially endangers existing facilities or structures, shoring, sheeting and bracing shall be incorporated as designed by a qualified engineer and a copy of the design (calculations and drawings etc.) shall be submitted to the Engineer. Boulders, rocks, and any other objectionable material encountered during excavation shall be removed. In the event that during the progress of the work, loose or improperly compacted soil is encountered at the bottom of structure foundation levels, or adjacent thereto, such material shall be completely removed within the limits as directed by the Engineer and shall be backfilled with suitable fill material or concrete as directed by the Engineer.
- B. All structural backfills shall be placed in dry conditions. Equipment for placing of backfill shall produce the specified compaction and shall be of the type and capacities as required and approved by the Engineer. Heavy equipment shall not be operated within 1 m of any structure. Vibration rollers shall not be used within 1.5 m of any structure. All working areas shall be protected from damage by water and site drainage shall be maintained at all times.

Part 2 Products

2.01 Backfill

- A. Structural fill material shall be obtained from the excavations and/or from suitable off-site sources and shall have a liquid limit not more than 25 percent and a plasticity index not more than 6 percent. The material shall consist of uniform readily compactible material free from vegetable matter, building rubbish and frozen material, or materials susceptible to spontaneous combustion. It shall be free from plastic fines and weakly cemented lumps of sand and have a smooth grading curve within, and sensibly parallel to, the grading envelope below:

Sieve Size	% by Mass Passing
75 mm	100

37.5 mm	85 - 100
10 mm	45 - 100
5 mm	25 - 85
0.6 mm	8 - 45
0.075 mm	0 - 10

2.02 Water

Water used for compacting fill, or for washing crushed stone shall be clean and free from oil, grease, organic matter, suspended fine sediment and other deleterious substances.

Part 3 Execution

3.01 Control of Water

All excavation and construction of structures and backfill shall be carried out in the dry as described in Section 02200.

3.02 Excess Excavation to be Made Good

- A. The Contractor, at his own expense, shall remove from the Site all material resulting from excess excavations below that required for the foundation, or bedding and shall make good the same with concrete or suitable fill material as may be required by the Engineer.
- B. Where, due to site conditions, an alternative method for supporting the foundations or beddings, may be possible the Contractor shall provide three copies of a design report by a competent engineer together with all calculations demonstrating the sufficiency of the proposals. No alternative proposals shall be undertaken except with the Engineer's consent and such consent shall in no way relieve the Contractor from any of his contractual obligations and responsibilities.

3.03 Supporting Structure Excavations

- A. Suitable and practically watertight cofferdams shall be used wherever water or water-bearing strata are encountered above the elevation of the bottom of the excavation. The Contractor shall submit shop drawings showing his proposed method of cofferdam construction at least two weeks prior to starting excavation.
- B. shall employ a qualified engineer to prepare the shop drawings who is registered in the country or who is acceptable to the Employer. The engineer who prepares the shop drawings shall be familiar with cofferdam construction and shall include his qualifications for the preparation of such a submittal. The shop drawings shall be complete with all details, design calculations, and description of construction and include all necessary particulars.
- C. Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottoms of the footings; or when footings are to be founded on or in rock, the cofferdam construction shall be placed at least to the level of top of rock or the bottom of

excavation in rock to suitably develop a stable cofferdam and shall be well braced and as 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.

- D. When conditions are encountered which 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. In the event that weighted cribs are employed and the weight is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage 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.

3.04 Backfilling

- A. Earth fill shall not be placed until the required excavation and foundation preparation have been completed and the foundation and/or structure to be backfilled has been inspected and approved by the Engineer. Fill shall be placed in approximately horizontal layers of thickness that can be uniformly compacted by the equipment used but of maximum 200 mm loose thickness. Hand compacted fill, including fill compacted by manually directed power tampers, shall be of maximum 100 mm loose thickness. Fill adjacent to structures shall be placed in a manner which will prevent damage to the structures and will allow structures to assume the loads from the fill gradually and uniformly. The height of the fill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure.
- B. Backfill shall be compacted to not less than 95 percent of maximum dry density.

3.05 Inspection by the Engineer

- A. When the specified levels of structure excavation are reached, the Engineer will inspect the ground exposed. If he considers that any part of the ground is by its nature unsuitable, he may direct the Contractor to excavate further and to refill the further excavation with such materials as he may direct. Such further excavation will not be held to be excess excavation. Should the bottom of any trench or structure excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. In this case the cost of the extra excavation and of the additional foundation materials required will be the Contractor's responsibility if necessitated by his negligence.

End of Section 02222

Section 02520: Road works

Part 1 General

1.01 Description

B. The work included in this Section comprises furnishing all plant, labour, equipment appliances and materials and performing all operations in connection with:

- 1 Precast Concrete Kerbs
- 2 Paving Blocks
- 3 Access Roads
- 4 Internal Roads
- 5 Public roads not to be reinstated by the Road Authority
- 6 Traffic Markings

1.02 Submittals

A. The following product data shall be provided:

1. manufacturer's specifications, test certificates and installation instructions for geotextile fabric,
2. for precast concrete kerbs and paving blocks the manufacturer's specifications, installation instructions and test sheets for each consignment,
3. details of proposed sources for approval of aggregates,
4. for bitumen the manufacturer's specifications and test certificates,
5. for traffic marking paint an acknowledgment that products submitted meet requirements of standards referenced together with the manufacturer's application and surface preparation instructions.

B. The following samples shall be provided and the Contractor shall allow fourteen days for Engineer's review of samples:

1. geotextile fabric - three samples of materials proposed,
2. precast concrete kerbs - one sample for each type,
3. paving blocks - three samples of materials proposed,
4. aggregates - samples of all aggregates for testing and these shall be taken in the presence of the Engineer's Representatives,
5. traffic markings - 5 litres paint and 0.5 kg of glass beads proposed.

1.03 Delivery, Storage and Handling

A. Materials shall be delivered in factory labeled packages indicating name, brand, type, size and color. Deliveries shall be sequenced to avoid project delays and to permit proper co-ordination of the work.

B. Geotextile fabric shall be protected against direct sunlight. The edges of precast concrete kerbs/paving blocks shall be protected to prevent staining, chipping or spillage of concrete.

1.04 Mock-up

A 15 sq m mockup of paving layout shall be provided and located where directed. It shall comprise sand setting bed, paving blocks and accessories to pattern-indicated showing range of shades, colour, and texture of pavers. The accepted mockup may become part of the work.

1.05 Quality Assurance

The manufacturer of paving blocks and precast kerbs shall be a company specializing in manufacturing with at least three years experience. The installer shall be a specialist in installing exterior pavers with three years experience.

Part 2 Products

2.01 Sub-grade

All materials within the top 450 mm below sub-base level shall be an approved material of C.B.R. minimum 25 compacted in accordance with as specified here-in.

2.02 Geotextile Fabric

Fabric shall be needled polypropylene thermally bonded of approved grade. It shall be stabilized against ultra violet light, inert to commonly encountered chemicals and chemical properties of the in-situ soil and water. It shall conform to the following minimum requirements:

1	weight	140g/m ²
2	thickness under load (2kN/sq.m)	0.95 mm
3	permeability at 10 cm water column	90 l/sq.m/s
4	tensile strength:	
	longitudinal direction	7 kN/m
	transverse direction	8 kN/m

2.03 Precast Concrete Kerbs

- A. Kerbs shall conform to BS 7263: Part 1: 1994 and materials shall conform to Section 03300. Concrete shall have a 28 days cube strength of 40 N/mm².
- B. Non-mountable kerb, dropped kerb, flush kerb and heel kerb elements shall only be precast from concrete produced in a fully automatic batching plant. Non-mountable and dropped precast kerbs shall be formed by elements 900 mm long where required to be laid in straight lines. These may be reduced to 250 mm long where required to be laid to curves depending on the radii of the curves. Units shall be fabricated using steel or other approved molds in compliance with the approved manufacturing and testing procedures. Quality control recommendations and dimensional tolerance shall be in accordance with BS 7263:Part 1. Units shall be cured by either: low pressure steam; steam vapor; radiant heat and moisture; or other similar process.
- C. Exposed-to-view finish surfaces of precast concrete members shall be fair faced, uniform in color and appearance. Blemishes such as non-uniformity, staining, or surface cracking shall be minimised. Small surface holes, normal form joint marks, minor chips, and spalls are acceptable. Major or unsightly imperfections, honeycombs, or structural

defects are not acceptable. Defective items shall be repaired or replaced as directed by the Engineer. Tolerances of manufacture shall be 3 mm in any one dimension and end faces shall be truly perpendicular to the base.

2.04 Paving Blocks

- A. Materials shall conform to BS 6717: Part 1 and thicknesses shall be 60 mm on side walks and 80 mm on access roads and parking areas unless otherwise shown on the Drawings or instructed by the Engineer. The average strength of 10 blocks tested in accordance with BS 6717: Part 1 shall be not less than 49 N/mm² and the strength of any individual block shall be not less than 40 N/mm². The water absorption average of three specimens tested in accordance with ASTM C140 shall not be greater than five percent. No individual result shall be greater than seven percent.
- B. The sand setting bed, which shall be obtained from a single source, shall consist of sharp sand containing not more than three percent silt and clay by weight and 10 percent retained on 4 mm sieve. Permissible limits expressed as a percentage by weight shall be: sulphates (as SO₃) - max 0.3 percent and chlorides (as Cl) - max 0.5 percent. The sand shall be allowed to drain before use and shall be covered with suitable sheeting to minimize moisture changes.

2.05 Access Roads

- A. Granular sub-base shall be hard, durable natural/screened gravel or crushed stone, free of clay balls or other deleterious substances. Grading shall be as follows, when tested in accordance with BS 812 : Part 103.

Sieve Size	% By Weight Passing
75 mm	100
37.5 mm	85 - 100
9.5 mm	40 - 85
4.75 mm	25 - 45
0.6 mm	8 - 25
0.075 mm	0 - 10

- B. Materials shall conform to the following requirements. Minimum test requirements shall be one sample tested every 1000 cum supplied and one insitu density test shall be made every 500 sq m of granular sub base laid.

Test	Standard	Limit
Sampling	ASTM D75	--
Liquid Limit	BS 1377 : Part 2 : Test 4.5	max 90%
Plasticity Index	BS 1377 : Part 2 : Test 5	max 15%
Organic Impurities	BS 1377 : Part 3 : Method 3	max 0.15%
Acid Soluble Sulphate (by wt. of agg)	BS 812 : Part 118	max 0.5%
Acid Soluble Chloride (by wt. of agg)	BS 812 : Part 117	max 1%
Flakiness Index	BS 812 : Part 105.1	max 35%
Elongation Index	BS 812 : Part 105.2	max 35%
Ten Percent Fines Value	BS 812 : Part III	min 50 kN
Los Angeles Abrasion	ASTM C131/C535	max 40%

Soundness (MgSo4)	ASTM C88	max 12%
Linear Shrinkage	BS 1377 : Part 2 :Method 6.5	max 3%
Compaction Test (Modified Proctor)	BS 1377 : Part 4 :Method 3.6	--
Field Density	BS 1377 : Part 9 : Test 2.2	min 95% MDD
C.B.R. at 95% of Modified Proctor Density (96 hour soaked)	BS 1377 : Part 4 Test 7	min 30%

- C. Granular road base material shall be hard, durable screens gravel or crushed stone, free from organic matter or other deleterious substances. Grading shall be as follows when tested in accordance with BS 812 : Part 103.

Sieve Size	% by Weight Passing
50 mm	100
37.5 mm	70 -100
28 mm	55 - 85
20 mm	50 - 80
10 mm	40 - 70
5 mm	30 - 60
2.36 mm	20 - 50
0.425 mm	10 - 30
0.063	5 - 15

- D. Material shall confirm with the following requirements. Minimum test requirements shall be one sample tested every 1000 cum supplied and one insitu density test shall be made every 300 sq m of aggregate road base laid.

Test	Standard	Limit
Sampling	ASTM D75	--
Liquid Limit	BS 1377 : Part 2 : Test 4.5	max 25%
Plasticity Index	BS 1377 : Part 2 : Test 5	max 6%
Organic Impurities	BS 1377 : Part 3 : Method 3	max 0.15%
Acid Soluble Sulphate (by wt. of agg)	BS 812 : Part 118	max 0.5%
Acid Soluble Chloride (by wt. of agg)	BS 812 : Part 117	max 1%
Flakiness Index	BS 812 : Part 105.1	max 35%
Elongation Index	BS 812 : Part 105.2	max 35%
Sand Equivalent Value	ASTM D2419	min 40
Los Angeles Abrasion	ASTM C131/C535	max 40%
Soundness (MgSo4)	ASTM C88	max 12%
Linear Shrinkage	AASHTO T92	max 3%
Compaction Test (Modified Proctor)	BS 1377 : Part 4 :Method 3.6	
Field Density	BS 1377 : Part 9 : Test 2.2	min 98% MDD
Maximum Dry Density	BS 1377 : Part 4 : Test 3.6	min 2.0g/cc
CBR at 100% of modified proctor density (96 hr. soaked)	BS 1377 : Part 4 : Test 7	min 80%

- E. Bitumen paving courses shall consist of the construction of the following hot-mix bituminous courses which consist of coarse aggregates, fine aggregates, filler material

and bitumen binder. Asphaltic concrete or dense bitumen macadam as indicated on the Drawings.

1. Coarse Aggregates:

- i. material shall be retained on a 4.75 mm sieve,
- ii. consist of crushed rock or crushed gravel,
- iii. shall be clean, hard, tough, durable and sound,
- iv. shall be of uniform quality and free from decomposed stone, shale, clay, lumps and other deleterious substances,
- v. crushed gravel shall consist of the product obtained by crushing material that has first been screened in such a manner that not less than 90 percent of the material to be crushed is retained on an ASTM 10mm sieve,
- vi. 100 percent by weight of each stockpile shall have one crushed face,
- vii. at least 50 percent by weight of each separate stockpile of aggregate shall have all faces crushed,
- viii. coarse aggregate shall have properties which comply with the following values:

Test	Standard	Base Course/	
Binder Course	Wearing Course		
Los Angeles Abrasion	ASTM C131/C535	max 30%	max 25%
Aggregate Crushing Value	BS 812 : Part 110	max 25%	max 20%
Soundness (MgSo4)	ASTM C88	max 10%	max 10%
Flakiness Index	BS 812 : Part 105.1	max 30%	max 25%
Elongation Index	BS 812 : Part 105.2	max 30%	max 25%
Water Absorption	ASTM C128/127	max 2%	max 2%
Acid Soluble Chlorides (by wt. Of agg)	BS 812 : Part 117	max 0.06%	max 0.06%
Acid Soluble Sulphate (by wt. of agg)	BS 812 : Part 118	max 0.4%	max 0.4%
Organic Impurities	BS 1377 : Test 3 : Method 3	max 0.05%	max 0.05%

2. Fine aggregates:

- i. consist of the material passing a 4.75 mm sieve,
- ii. fine aggregate including filler shall be obtained from 100 percent crushed gravel or crushed rock prescreened to exclude natural uncrushed fine material or weathered unsound fines,
- iii. use of dune sand shall not be permitted,
- iv. fine aggregates shall have properties which comply with the following values:

Test	Standard	Limit
Soundness (MgSo4)	ASTM C88	Max 10%
Plasticity Index	AASHTO T90	Non-Plastic
Acid Soluble Chlorides (by wt. of agg)	BS 812 : Part 117	Max 0.06%
Acid Soluble Sulphates (by wt. of agg)	BS 812 : Part 118	Max 0.4%

Sand Equivalent Value	ASTM D2419	min 40
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3. Filler material

- i. when the combined grading of the coarse and fine aggregates is deficient in material passing the AASHTO No. 200 sieve, mineral filler shall be added as approved by the Engineer at the Contractor's expense,
- ii. consist of finely ground particles of limestone or cement in accordance with ASTM D242,
- iii. shall be thoroughly dry and free from organic substances and clay,
- iv. shall meet the following grading requirements:

BS Sieve Size	ASTM Sieve Size	% By Weight Passing
600 micron	No. 30	100
300 micron	No. 50	95 – 100
150 micron	No. 100	90 – 100
75 micron	No. 200	70 – 100

4. Bitumen binder

- i. shall be penetration grade 60 – 70,
- ii. bitumen shall be prepared by refining crude petroleum by suitable method,
- iii. shall be homogeneous and free from water,
- iv. shall not foam when heated to 175°C,
- v. shall conform to the requirements of following values:

Test	Method	Min	Max	
	AASHTO	ASTM		
Penetration at 25°C 100g, 5 sec.	T49	D5	60	70
Flash Point, Cleveland Open Cup, °C	T48	D92	232	-
Ductility at 25°C, cm	T51	D113	100	-
Solubility trichloroethylene, %	T44	D2042	99	-
Thin film oven test 3.2 mm, 163°C, 5 hr loss on heating, %	T179	D2872	-	0.80
Penetration of residue % of original	T49	D5	54	-
Ductility of residue at 25° C, 5 cm/min, cm	T51	D113	50	-
Kinetic Viscosity (centistokes) at 135° C	T201	D2170	240	-
Softening Point (Ring Ball apparatus)	-	D36	48	52

- vi. no bitumen, other than that represented by the approved sample, shall be used by the Contractor except with the written consent of the Engineer,
- vii. blending of bitumen from different refineries will not be permitted.

5. Asphaltic Concrete

- i. when tested according to ASTM C117 and ASTM C136, the mixes shall conform to the following grading:

ASTM Sieve Size	% By Weight Passing	
	Base Course	Wearing Course
37.5 mm	100	-
25.0 mm	80 - 100	100
19.0 mm	62 - 92	86 - 100
12.5 mm	-	69 - 87
9.5 mm	45 - 75	58 - 78
4.75 mm	30 - 55	40 - 60
2.36 mm	20 - 40	25 - 45

0.85 mm	15 - 30	15 - 30
0.425 mm	10 - 22	10 - 22
0.18 mm	6 - 15	6 - 15
0.075 mm	2 - 8	2 - 8

- ii. use of sand in mixes will not be permitted,
- iii. combined mineral aggregate shall meet the following requirements:
- iv. sand equivalent value (ASTM D2419) determined after all processing except for addition of asphalt binder min 65 plasticity index BS 1377: Part 2: Test 5 Non-plastic
 - 1. gradings given in the above Table represent the extreme limits which shall determined suitability of aggregate for use from all sources of supply,
 - 2. aggregate as finally selected for use in the work shall have a grading within the limits designated in the above table as appropriate,
 - 3. base course limit may vary from the low limit on one sieve to the high limit on the adjacent or vice-versa with the Engineer's approval,
 - 4. wearing course shall be uniformly graded from coarse to fine.
- v. coarse aggregate, shall show no detrimental amount of stripping when tested in accordance with ASTM D 1664,
 - 1. minimum value of non stripped area shall be 95 percent,
 - 2. if stripping occurs, the aggregate shall be rejected. Approved method of treatment shall be carried out as specified to change the material from a hydrophilic to a hydrophobic state as directed by the Engineer. Approved additive shall be used with the bituminous binder.
- vi. when necessary to improve the coating of aggregate by bitumen, additives of approved type will be added to the bituminous material in such percentage as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with ASTM D1664. Approved additive will be used in accordance with Technical Specifications issued by the manufacturer and approved by the Engineer after appropriate testing,
- vii. no extra payment will be made for required anti-stripping additives,
- viii. design criteria :

Properties	Base Course	Wearing Course
Bitumen Content (% of total mix)	3.2 - 4.4	3.4 - 4.4
Marshall Specimens:		
Number of Compaction blow at each end of specimen.	75	75
Voids in total mix (VTM %)	4 - 8	4 - 8
Voids in mineral aggregate (VMA %)	min 13	min 15
Voids filled with Bitumen (VFB %)	50 - 65	50 - 75
Stability (kg)	min 1000	min 1200
Flow (mm)	2 - 4	2 - 4
Stiffness (kg/mm)	min 500	min 500
Loss of Marshall Stability by submerging specimens in water at 60° C for 24 hours compared to stability measured after submersion in water 60° C for 30 minutes.	max 25%	max 25%

Filler/Bitumen Ratio	0.6 - 1.5	0.6 - 1.4
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6. Dense Bitumen Macadam.

- i. when tested according to ASTM C117 and ASTM C136 the mixes shall conform to the following grading:

1. base course

BS Sieve Size (Mm)	% By Weight Passing		
	Finished Thickness (Mm)		
	65 - 80	50 - 60	35 - 45
50	100	-	-
37.5	95 - 100	100	-
28	70 - 94	90 - 100	100
20	-	71 - 95	95 - 100
14	56 - 76	58 - 82	65 - 85
10	-	-	52 - 72
6.3	44 - 60	44 - 60	39 - 55
3.35	32 - 46	32 - 46	32 - 46
0.300	7 - 21	7 - 21	7 - 21
0.075	2 - 8	2 - 8	2 - 8

2. wearing course

BS Sieve Size (Mm)	% By Weight Passing		
	Finished Thickness (Mm)		
	35 - 50	25 - 30	20
28	100	-	-
20	95 - 100	100	-
14	70 - 90	95 - 100	100
10	55 - 75	70 - 90	95 - 100
6.3	40 - 60	45 - 65	55 - 75
3.35	25 - 40	30 - 45	30 - 45
1.18	15 - 30	15 - 30	15 - 30
0.075	2 - 6	2 - 6	2 - 6

- ii. use of dune sand in mixes will not be permitted.
- iii. combined mineral aggregate shall meet the following requirements:
1. sand equivalent value (ASTM D2419) determined after all processing except for addition of asphalt binder min 65.
 2. plasticity Index BS 1377: Part 2: Test 5 Non-plastic
- iv. gradings given in Tables 9 & 10 represent the extreme limits which shall determine suitability of aggregate for use from all sources of supply. Aggregate as finally selected for use in the work shall have a grading within the limits designated in Tables 9 & 10 as appropriate. Combined gradings which approach maximum limits on some sieves and minimum limits on other sieves shall not be permitted,
- v. coarse aggregate, shall show no detrimental amount of stripping when tested in accordance with ASTM D1664. Minimum value of non stripped area shall be 95 percent. If stripping occurs, the aggregate shall be rejected. Approved method of treatment shall be carried out as specified

to change the material from a hydrophilic to a hydrophobic state as directed by the Engineer. Approved additive shall be used with the bituminous binder.

- vi. when necessary to improve the coating of aggregate by bitumen, additives of approved type will be added to the bituminous material in such percentage as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with ASTM D 1664. Approved additive will be used in accordance with Technical Specifications issued by the manufacturer and approved by the Engineer after appropriate testing.
- vii. no extra payment will be made for required anti-stripping additives.
- viii. design criteria:

Properties	Base Course	Wearing Course
Bitumen content (% of total mix)	3.2	3.5 - 4.1
Marshall specimens: No. of Compaction blow at each end of specimen	75	75
Voids in total mix (VTM %)	7 - 11	6 - 9
Voids in Mineral Aggregate (VMA %)	14 - 20	14 - 20
Voids filled with Bitumen (VFB %)	48 - 60	48 - 60
Stability (kg)	min 750	min 1000
Flow (mm)	2 - 4	2 - 4
Stability/Flow Ratio (kg/mm)	min 270	min 320

7. Prime Coat.

- i. bituminous prime coat shall consist of supplying and applying liquid asphalt to a previously prepared and approved sub-grade; sub-base or aggregate base course in accordance with this Specification.
- ii. Material
 - 1. medium curing cut back asphalt MC-70,
 - 2. conform to ASTM D2027 as modified by Table below or as directed by the Engineer:

Test	Method	Limits	
		Min	Max
Sybolt Furol Viscosity at 50° C, sec.	AASHTO T72	60	120
Flash Point, Tag open Cup, °C	AASHTO T79	38	-
Distillation:	AASHTO T78		
Distillate (% of total distillation to 360° C.)			
To 225° C		-	20
To 260° C		20	60
To 315° C		65	90

- 3. Residue from distillation to 360° C, % by volume difference
AASHTO T78 55 -
- 4. Tests on residue from distillation:
- 5. Penetration at 25° C, 100g 5 sec. AASHTO T49 120 250
- 6. Ductility at 25° C, cm AASHTO T51 100 -
- 7. Solubility in trichloroethylene, % AASHTO T44 99 -
- 8. Water content, % by volume AASHTO T55 - 0.2

8. Tack coat

- i. bituminous tack coat shall consist of supplying and applying emulsified asphalt diluted with an equal quality of water (1:1) to a previously prepared:
 1. bituminous base course,
 2. binder course or,
 3. existing bituminous surface in accordance with this specifications,
 4. material:
 - a. slow setting emulsified asphalt,
 - b. grade SS-1h (anionic) or CSS-1h (cationic),
 - c. conform to ASTM D977:

Test	Method	Limits	
		Min	Max
Saybolt Furol Viscosity at 25° C, sec.	AASHTO T72	20	100
Storage Stability Test, 24 hrs, %	AASHTO T59	-	1
Residue by distillation	AASHTO T78	57	-
Tests on residue from distillation:			
Penetration 25° C, 100g 5 sec.	AASHTO T49	40	90
Ductility 25°, cm	AASHTO T51	40	-
Solubility in trichloroethylene, %	AASHTO T44	97.5	-

sampling shall be in accordance with ASTM D140.

2.06 Traffic Markings

Thermoplastic materials shall conform to BS 3262 : 1989 : Part 1 except where modified in this Specification.

Ballotini shall be in accordance with BS 6088 : 1981.

Road marking material shall consists of:

- 1 light coloured aggregate,
- 2 pigment and extender bound together,
- 3 hard wearing resins, plasticised with oil as necessary,
- 4 composition of material:

5aggregate	40 parts
Ballotini	20 parts
pigment and extender	20 parts
binder	20 parts

- A. Grading of various ingredients shall be such that the final product, when in a molten state, can be sprayed on the surface in accordance with BS 3262:1989.
- B. Aggregate shall consist of white silica sand; crushed calcite; calcined flint or quartz or other approved aggregate. Colour shall comply with the requirements laid down in paragraph 4b of BS 3262:Part I.
- C. Ballotini shall be reasonably spherical; free from flaws; not less than 80 percent shall be transparent glass and grading shall be in accordance with BS 6088:1981.

- D. Pigment shall be titanium dioxide in accordance with paragraph 6a(i) of BS 3262: Part 1 and shall be not less than 10 percent by weight of the mix.
- E. Extender shall be whiting in accordance with paragraph 6b of BS 3262: Part 1. The total content of pigment and extender shall be 18 to 22 percent in accordance with paragraph 6c of BS 3262: Part 1.
- F. Binder shall not contain more than 5 percent of resin or other acidic material and shall consist mainly of hydrocarbon resins plasticised with mineral oil.
- G. Resins shall be of a colour at least as pale as Grade WG resin; shall have an acid value not greater than 2 and must pass the heat stability test described below.
- H. Oil used as plasticiser shall be a mineral oil with colour and viscosity as defined in paragraph 7a (ii) of BS 3262: Part 1. It shall be at least as pale as grade 4 on the PRS shellac and varnish "A" disc; $\frac{1}{2}$ to $3\frac{1}{2}$ poises at 25° C viscosity. When heated for 16 hours at 150° C it shall not darken excessively.
- I. Softening point of the binder shall be used only as a guide to quality control.
- J. Behavior of the thermoplastic shall be judged from the performance tests described below. Viscosity of the melted binder at the spraying temperature must be such to produce a thermoplastic mix of the required spraying properties. Composition of the laid material as found on analysis shall comply with the requirements of Table 1 of BS 3262 : Part 1.

1. proportion of constituents

	By Weight	
Constituent	Minimum	Maximum
Binder	18	22
Aggregate, pigment and extender and ballotini	78	82

2. grading of combined aggregate pigment and extender:

	By Weight Passing	
Sieve Size	Minimum	Maximum
No. 20	100	-
No. 30	75	95
No. 52	35	65
No. 200	25	35

3. temperature limits imposed by BS 3262 : Part 1 for materials based on resin shall not apply. Temperatures up to 220° C may be used. At these temperatures the material shall not discolour in the time required for its use,
4. containers shall be made of a material which does not contaminate the contents and will protect the contents from contamination,
5. capacity of each container shall be not less than 25 kg or more than 100 kg.,
6. each container shall be clearly marked with the manufacturer's name, batch number and date of manufacture.

K. Performance requirements

1. thermoplastic material shall meet the performance requirements of the following:

Property	Minimum	Minimum
Density (Mg/Cu.m)	2.0 (approx)	-
Open flashpoint °C	230	-
Softening point (Ring and ball ASTM D36) °C	95	-
Luminance	75	-
Flow resistance after 48 hours at 40° C	-	25
Abrasive wear, 9/100 revs	-	0.3
Skid resistance	45	-

L. Testing of thermoplastic material

1. all specimens shall be prepared by carefully heating a representative sample to a temperature of (softening point + 50°C), stirring thoroughly to avoid segregation and used without delay,
 - a. material shall be cast on to a suitable flat, glossy surface coated with a colourless release agent to give a slab 100 mm square by 3 mm thick. Luminance of the cast face, with reference to that of a block of magnesium oxide (luminance factor 100) shall be measured with the sample illuminated by a tungsten light source at an angle of 45° viewed at right angles by a selenium barrier layer phot-electric cell.
 - b. for flow resistance, material shall be cast into a conical mould having an apex angle of 60° and a vertical height of 100 mm. After cooling and setting for 24 hours the cone shall be removed from the mould, placed on a flat level surface and maintained at a temperature of 23 + 2°C for 48 hours.
 - c. for impact resistance, a 3 mm thick coating of material shall be screeded on to a monel alloy panel 1.25 mm thick, previously coated with rubberised bitumen emulsion. The impact instrument, a 4.7 kg weight, shall be dropped vertically through 250 mm on to the surface of the panel, striking the surface with a hemispherical indenter of radius 6 mm. Panel shall be retained by a metal block drilled to allow the indenter to strike the panel, with the depth of indentation limited to 2 mm. Five panels shall be tested and no fracture shall result from impact. A crack not longer than 2 mm will be accepted provided there is a smooth indentation in the material.
 - d. for abrasion resistance, a 3 mm thick coating of material shall be screeded on to a monel alloy panel and subject to wet (water lubricated) abrasion at 23°C on a Taber model 503 standard abrasion tester using H-22 calibrate wheels, refaced between tests. Loss in weight after two successive tests of 100 revolutions shall be recorded and the average taken as the abrasive wear.
 - e. for skid resistance, a 100 mm wide line of material 1.5 mm thick shall be screeded on to a flat, level base for a minimum length of 800 mm. After cooling to ambient temperature the skid resistance shall be measured using the TRRL Portable Tester as described in Road Note 27. Measurements shall be made on different parts of the specimen, corrected for temperature effects, and the average recorded.

2.07 Road Marking Paint (for Traffic Diversions, etc.)

- A. These shall be either chlorinated rubber, one pack epoxy or alkyd based and shall be suitable for applying by brush or mechanical means to cement concrete or bituminous pavement to give a chemically stable film of uniform thickness.
- B. White paint shall contain not less than 6 percent by mass of titanium dioxide as a pigment and shall conform to type A (anatase) or type R (rutile) specified in BS 1851.
- C. Yellow paint shall be standard colour BS 381C No. 355, except where an alternative NMshade has been specified. It shall contain not less than 6 percent by mass of a suitable yellow pigment.

Part 3 Execution

3.01 Excavation

- A. Other Clauses of Division 2 apply except as modified hereunder. The Contractor shall include excavation as required to provide a smooth, gentle slope to meet the existing adjacent ground surface. For the sub-grade preparation Contractor shall scarify a layer of an adequate area and suitable depth not less than 300 mm. Soil shall be pulverized, mixed, shaped, compacted and finished, all in accordance with the Specifications.
- B. Unless otherwise specified or approved by the Engineer, no materials excavated shall be used as fill material but shall be disposed of by the Contractor. When unsuitable material is directed to be removed by the Engineer, the surface of the cut section shall be compacted to 95 percent MDD according to ASTM D1557 Method D, to a depth of 150 mm below surface of cut before placement of approved borrow material.

3.02 Placement of Borrow Materials, Backfilling and Filling

- A. Where borrow or fill materials are to be placed and compacted on hillsides, or where new fill is to be compacted against existing embankments, or where fill is built one-half width at a time on slopes steeper than three horizontal to one vertical, the slopes of the original hillside, old or new fill, shall be cut into as the work is brought up in layers (benching). Grades shall slope according to the Drawings. Material thus cut out shall be incorporated and compacted with the new fill.
- B. Borrow materials or fills shall be formed in horizontal layers of uniform thickness. Work shall be carried out to adhere to the slopes, levels, depths indicated. After adjustment of the moisture content to that required to attain maximum density, the loose material shall be compacted to obtain the specified density.
- C. Placement of borrow materials or fills at points inaccessible to normal compaction equipment shall be made in horizontal layers of loose material not exceeding 100 mm in depth and thoroughly compacted by the use of mechanical tampers.
- D. Prior to the placement of any borrow materials, the Contractor shall construct trial compaction tests as directed by the Engineer. Borrow material used in the trials shall be

with the proposed borrow material. Compaction equipment to be used shall be that specified and acceptable to the Engineer. The object of these trials shall be to determine the optimum moisture content and the relationship between the number of compaction equipment passes and density for the proposed borrow materials.

- E. Density to which borrow material or fill layers shall be compacted is as required to comply with the requirements of paragraph 3.03 here-in.
- F. Borrow material which does not contain sufficient moisture to obtain the required compaction shall have additional water incorporated therein by the use of approved sprinklers and mixing.
- G. Material containing an excess of the amount of moisture required to obtain the necessary compaction shall not, without written approval of the Engineer, be incorporated in the fill until it has been allowed to dry prior to compaction. Drying of wet material may be expedited by disking or other approved methods.
- H. Compaction of borrow materials or fills shall be carried out at moisture content determined by the Engineer. In forming the embankments the Contractor shall ensure that the work can be drained free of rainwater and shall make allowances in the height and width of the work for any swelling or shrinkage.
- I. When an embankment or filled area has achieved settlement and requires additional material to bring it up to the required formation level, the top of the borrow or fill shall be thoroughly scarified before the placement of additional material when the depth of the additional material is less than 300 mm.

3.03 Compaction

- A. The Contractor shall carry out the compaction of borrow materials or fills as specified after grading and leveling the surface to be compacted. In areas to be filled, compaction shall include adding necessary fill, water, and other materials as required, 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 hereinafter. Procedure outlined below shall not relieve the Contractor of his duties to determine the most suitable procedure for compaction. All such procedures shall be subject to the approval of the Engineer.
- B. After carrying out the grading, leveling, scarifying, pulverizing, and other work as required, of the fill layer to be compacted as per specifications, the Contractor shall add the necessary amount of water to permeate the pulverized fill in the quantity required, all in accordance with the directions of the Engineer. Fill shall then be thoroughly turned over after adding each lot of water so as to achieve a homogeneous moisture content in the whole thickness of the layer.
- C. Before compacting, samples from the pulverized fill will be taken and tested according to laboratory testings, (field testing using "Speedy Moisture Device" or similar instrument giving direct readings for the filled moisture content may be used for guidance only), in order to establish the natural moisture content. In the event that it is more than Optimum

Moisture Content, the area of sub-grade represented by this sample shall be scarified and aerated until the moisture content is within + 2 percent of the Optimum Moisture Content. Then the fill shall be primarily leveled in order to commence fill compaction.

- D. After primary leveling compaction shall be commenced by means of approved rollers depending on the type of material being compacted in order to obtain 95 percent of maximum dry density. Placement of borrow materials or fills shall be in layers not exceeding 150 mm compacted thickness. When tested in place, borrow material shall have a minimum density of 95 percent of maximum dry density to a minimum depth of 300 mm below the top of sub-grade. Borrow material shall be tested and shall have a California Bearing Ratio (CBR) of 25 as a minimum.
- E. Rolling shall be carried out in the direction of the road axis until the fill 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 superelevated, rolling shall commence from the lower side and continue to the higher side. In order to compensate for the amount of water lost in evaporation in the course of compaction, additional quantities of water shall be added as required.
- F. The surface shall thereafter be leveled longitudinally and transversely by motor graders and finally rolled to achieve uniform compaction free from undulations, soft spots and depressions.

3.04 Sub-grade Preparation

- A. All sub-grade material within the upper 450 mm below the top of sub-grade elevation shall have a minimum California Bearing Ratio (CBR) of 25 when tested in accordance with BS 1377: Part 4, Method 7. When the upper 450 mm below the sub-grade elevation of earth cut is found to be incapable of compaction as specified such sub-grade material shall be removed and replaced.
- B. After the foregoing work has been accomplished, the entire sub-grade shall be shaped to a smooth uniform surface. Excess material, which cannot be disposed of by normal drifting to the low spots during blading and shaping operations, shall be removed and disposed of by placing it in sub-grade areas deficient in materials and shall be watered and compacted as necessary to yield a true finished sub-grade as described above.
- C. Once prepared, the sub-grade shall be maintained in the finished condition until the first succeeding course of sub-base or base material has been placed. The Contractor shall take all precautions necessary to protect the sub-grade from damage. Hauling over finished sub-grade shall be limited to that which is essential for construction purposes. The Contractor shall protect the prepared sub-grade from both his own and public traffic. The Contractor shall maintain the sub-grade by blading and rolling as frequently as may be necessary to preserve the sub-grade in a completely satisfactory condition.

3.05 Geotextile Fabric Installation

In areas where the Engineer considers and deems the use of geotextile fabric necessary, the Contractor shall furnish and place geotextile fabric as specified herein and as directed by the

Engineer. Sub-grade surface to receive the geotextile fabric shall be prepared by spreading sand to a relatively smooth condition free of obstruction, depressions, and debris. Geotextile fabric shall not be laid in a stretched condition, but shall be laid loosely with the long dimension parallel to the centre line of the pavements. In the event the width of the proposed area for fabric requires more than one panel width of fabric, the panels shall be overlapped a minimum of 15 percent of the panel width. Longitudinal joints in the fabric shall have an overlap of 500 mm. To prevent slippage of the overlapping fabric, the areas of overlap shall be stabilized as approved by the Engineer with pins, anchor blocks, or aggregate piles. In the event construction machinery is used to place the fabric, the working platform for the machinery shall be the soil sub-grade and not the previously laid fabric. Prior to placement of the aggregate material the Contractor shall spread a layer of sand over the geotextile fabric as directed by the Engineer. Aggregate material shall not be dumped directly on the fabric, nor shall the haul trucks run on the fabric. Aggregate shall be spread by a bulldozer or front end loader. Blade or bucket shall be kept sufficiently high so that the aggregate is not being pulled over the fabric, but being dropped at a minimum height to the satisfaction of the Engineer. Fabric damaged or displaced before or during installation or during placement of overlying aggregate material shall be replaced or repaired at the Contractor's expense and to the satisfaction of the Engineer.

3.06 Installation of Precast Concrete Kerbs

- A. Kerbs shall be set to the lines and grades shown on the Drawings. Under no circumstances will it be permitted for levels to be set by direct measurement from pavement layers.
- B. Unless otherwise indicated, elements shall be laid either directly onto a wet concrete base or on to a cement, sand (1:3) mortar bedding, 25 mm thick on a previously laid concrete base on approved sub-grade. Dimensions of the base shall be as shown on the Drawings. Concrete base shall be constructed with Grade 20 Concrete.
- C. Unless otherwise indicated, after kerbs units have been laid a contiguous backing of Grade 20 Concrete shall be poured for the elements using steel forms.
- D. No pavement layers shall be laid against kerbing until such time as the backing is complete, back filled and approved by the Engineer.
- E. Joints between radius kerbs, shall have a clear width of 4 mm and be filled with a cement, sand (1:3) mortar with 1/5 part hydrated lime and sufficient water to make the mixture plastic and easily smoothed. A grooving tool shall be used to produce a smooth, circular section groove not more than 3 mm deep in all joints. Grouted joints shall be cured by an approved method to the Engineer's satisfaction. Joints between straight kerbs shall not be filled.
- F. Immediately after any concrete is in place and for 7 days thereafter the kerbs, base backing and mortared joints shall be fully cured and protected from drying out and against the harmful effects of weather, including rain and rapid temperature changes. Method of protection shall be subject to the Engineer's approval. Use of coloured curing membranes will not be permitted. Concrete not properly cured and protected will be rejected and shall be removed from the works.

- G. At each 9 metres or as directed by the Engineer or shown on the Drawings, the joint between kerbs shall be filled with an approved joint filler 10 mm thick to form an expansion joint. Filler shall extend through the kerb, bed, backing and channel. Shall be trimmed to the finished shape of the kerb and channel.
- H. At the end of any kerb run, the end kerb section shall be sloped down to ground level, if applicable, angled away from the road at 30 degrees.
- I. Where specified kerbs shall be painted.
- J. Any excavated surface for the concrete bedding shall be watered and compacted to a minimum of 95 percent MDD.

3.07 Installation of Paving Blocks

- A. Paving blocks shall be laid on the sand laying course in such manner as not to disturb the blocks already laid. Each block shall be placed firmly against its neighbour so that they fit closely together. Joints between blocks shall not exceed 3 mm. Laying of the paving blocks shall commence at right angles to the main pavement axis starting at one end of the area. Shall be laid in a herringbone pattern unless otherwise shown on the Drawings or instructed by the Engineer at 45° to the main pavement axis.
- B. Where blocks do not fit the edge restraints or other obstructions such as manholes or upstands the gaps shall be filled using cut blocks.
- C. Blocks shall be cut using only a mechanical block splitter.
- D. Dimensional accuracy, uniformity of joint gaps, alignment and squareness shall be checked after laying the first three rows of blocks and thereafter at regular intervals. If joints begin to open the blocks shall be knocked together using a hide mallet.
- E. After each 20 sq.m or such area that has been agreed with the Engineer, laid blocks shall be compacted to the required levels using a plate vibrator. Plate vibrator shall have a plate area of 0.20 to 0.35 m², a compaction force of 12-24 kN and a frequency of approximately 75 to 100 Hz.
- F. A minimum of two passes of the plate vibrator shall be made in each direction, i.e. at 90 degrees to each other. Vibration shall continue until no further compaction of the sand layer is apparent. Laying course shall have a compacted thickness of 50 mm. Fine dry sand with a particle size of 0.3 mm shall then be brushed over the paving. Further passes of the plate vibrator made in each direction, until the sand is no longer absorbed into the joints. Plate vibrator shall not pass closer than 1 m to a temporarily unrestrained edge during laying. No paving shall be left uncompacted overnight except for the 1 m strip at the temporarily unrestrained edge.
- G. On completion, the finished surface level, shall be within 5 mm of the design level. Maximum deviation within the compacted surface, measured by a 3 m straight edge shall not exceed 3 mm. Level of any two adjacent blocks shall not differ by more than 1

mm. Any areas of paving which do not comply with these tolerances shall be removed. Sand laying course adjusted and the paving blocks relaid to the correct levels.

3.08 Road Construction

- A. Granular sub-base shall be:
 - 1. delivered to the roadbed as uniform mixture
 - 2. spread in layers or windrows.
 - 3. segregation shall be avoided.
 - 4. free from pockets of coarse or fine materials.
 - 5. spread by finisher and or grader or their approved mechanical methods.
 - 6. watered, shaped to a compacted thickness not exceeding 150 mm and compacted to the required grade and cross-section.
 - 7. compacted with procedure and plant to the satisfaction of the Engineer. At the time of compaction the moisture content of the laid material shall not vary by more than + 2 percent of the Optimum moisture content.
 - 8. compacted to not less than 95 percent of the maximum density determined in accordance with BS 1377: Part 4: Method 3.6. Surface on completion of compaction shall be well closed, free from movement under compaction plant and free from ridges cracks or loose material. Finished surfaces of the road sub-base shall not vary at any point more than 10 mm above or below the grade established by the Engineer.
 - 9. maintained in a condition satisfactory to receive any subsequent base or surfacing material.
- B. Sub-base which does not conform to the above requirements shall be reshaped or re-worked, watered and thoroughly re-compacted to conform to the specified requirements.
- C. Granular road-base shall be constructed as follows:
 - 1. it shall be spread on sub-grade or sub-base as shown on the Drawings and as approved by the Engineer. Layers shall not exceed 150 mm in compacted thickness. Material shall be handled in a manner which avoids segregation and any segregated materials shall be re-mixed until uniform. Suitable precautions shall be taken to prevent rutting of the sub-grade or sub-base during the spreading. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operations will cause cutting or rutting of the sub-grade or cause contamination of aggregate road-base material,
 - 2. road-base which has been placed on a sub-grade or sub-base not approved by the Engineer shall be removed at the Contractor's expense,
 - 3. moisture content of the aggregate road base material shall be adjusted prior to compaction, by watering with approved sprinkler trucks or by drying out, as directed by the Engineer, to that required to obtain the specified density for aggregate road-base,
 - 4. it shall be compacted by means of approved compaction equipment progressing gradually from the outside of the road towards the centre with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density. Rolling shall be accompanied by sufficient blading in a manner

approved by the Engineer, to ensure a smooth surface free from ruts or ridges and having the proper section and crown,

5. the surface of the material shall on completion of compaction be well closed, free from movement under the compaction plant and free from compaction planes, ridges, cracks, or loose material,
 6. any areas inaccessible to normal compaction equipment shall be compacted by means of mechanical tampers until satisfactory compaction is obtained,
 7. the Contractor shall program his operations to avoid the drying out of the sub-base during construction. If any layer of aggregate road-base material, or part thereof, is permitted to dry out after compaction, or does not conform to the required density or finish, the Contractor shall, at his own expense, rework, water and recompact the material, as directed by the Engineer, to the density specified before the next layer of aggregate road-base or subsequent pavement layers are placed,
 8. if directed by the Engineer, prior to the commencement of the aggregate road-base operations, the Contractor shall construct trial lengths not to exceed 250 metres. Materials used in the trials shall be those approved for use as aggregate road-base. Equipment used shall be that according to the Contractor's approved detailed program of work. Trial lengths may not form part of the permanent works but may be permitted in the construction of temporary detours of sufficient length. The Contractor may proceed with the aggregate road-base work only after the methods and procedures established in the compaction trials have been approved by the Engineer. The object of these trials is to determine:
 - a. adequacy of the Contractor's equipment,
 - b. loose depth measurements necessary to result in the specified compact layers depths,
 - c. field moisture content,
 - d. relationship between the number of compaction passes and the resulting density of the material.
 9. immediately prior to the placing of the first layer of the next pavement course on to the aggregate road-base the final layer of aggregate road-base shall be at the specified density and to the required grade and section. In order to maintain these requirements while placing the next course it may be necessary to water and reshape the surface of the aggregate road-base. The work shall be at the Contractor's expense. The surface of the finished aggregate road-base will be tested with a 3 m straightedge by the Engineer at selected locations. Variations of the surface from the testing edge of the straight edge between any two contacts with the surface shall at no point exceed 12 mm when placed on or parallel or perpendicular to the centreline of the roadway. The cross section as shown on the Drawings shall not vary by more than 10 mm from the required elevation. All humps and depressions and thickness deficiencies exceeding the specified tolerance shall be corrected by removing the defective work or by adding new material as directed by the Engineer.
- D. Mix for bituminous paving courses shall be designed using Marshall tests and field trials with the following recommendations shall be taken into account:
1. for base course the Marshall shall be modified by substituting all aggregate sizes over 25 mm with an equal weight of sizes in the next lower grading size,

2. combined aggregate gradation should be adjusted within the allowable limits to achieve maximum stability whilst not going below the minimum requirement for void content,
3. minimum bitumen binder content according to the results of the Marshall Method of Mix Design should be used provided that it will still satisfy the durability, the stability and the void content requirements,
4. prior to final approval, the proposed job mix, but with a bituminous content at the upper percentage limits shall be compacted to refusal (400 to 600 blows). The resulting voids in the mix shall not be less than two percent for asphaltic concrete and three percent for DBM,
5. final job mix must display the Marshall characteristics as specified for asphaltic concrete and DBM,
6. fix formula must take into consideration the absorption of bitumen into the aggregates. For calculations for voids in the mix (VIM), the Rice Method as per ASTM D2041 and by using maximum theoretical specific gravity as prescribed by ASTM D2041 shall be used. For calculation of voids in the mineral aggregate (VMA) the equations as mentioned in Asphalt Institute Manual MS-2 shall be used. Voids filled with bitumen (VFB) shall be calculated using the following equation:

$$\text{VFB} = \frac{(\text{VMA} - \text{VIM}) \times 100}{\text{VMA}}$$

7. at least thirty days prior to the date he intends to begin production of plant-mix "Bituminous Paving Course" Mixes, and after receiving approval of the aggregates and bitumen from the Engineer the Contractor shall make a written request for the approval of the job-mix formula from the Engineer. The formula will be prepared by the Contractor under the supervision of the Engineer in the laboratory. The laboratory job mix formula shall fix single definite values for:
 - a. percentage of aggregate passing each required sieve size,
 - b. percentage of bitumen binder to be added to the aggregate,
 - c. temperature at which the mix is to be emptied from the mixer,
 - d. temperature at which the mix is to be delivered to the works site.
8. laboratory job mix formula shall be used for the basis of approval of the job standard mixture.
9. trials areas having lengths of at least 30 m and to the specified layer thickness shall be laid outside the area of the permanent work by the Contractor for the Engineer's approval, before the start of the permanent work. At least two samples of non-compacted material from the trial area shall be taken in accordance with AASHTO T-168 and shall be analyzed in the presence of the Engineer to determine:
 - a. aggregate grading
 - b. binder content
 - c. stability
 - d. flow
 - e. Marshall density
 - f. Voids
 - g. results shall be submitted to the Engineer for approval before further mixing or laying is carried out.
10. should the laboratory job mix formula after passing the mixing plant and laid and compacted with approved plant, fail to produce a satisfactory trial area, the mix

proportions may be modified by agreement with the Engineer, as necessary and within the requirements as applicable to produce a mix of satisfactory workability and acceptable surface finish. After approval of the trial area by the Engineer this mix shall be designated the 'Job Standard Mix' and shall thereafter be the approved mix.

11. all mixes produced shall conform to the Job Standard Mix approved by the Engineer, within the ranges of tolerance specified.
12. should a change in a material be encountered or should a change in a source of material be made, a new Job-Standard Mix shall be submitted by the Contractor and approved by the Engineer before the mix containing the new materials delivered. Job materials will be rejected if they are found not to have the characteristics required by the approved Job Standard Mix.

13. job mix tolerances shall be:

Aggregate retained on 4.75 mm sieve or larger	+ 5%
Aggregate passing 4.75 mm sieve and retained on 0.85 mm sieve	+ 4%
Aggregate passing 0.85 mm sieve and retained on 0.075 mm sieve	+ 2%
Aggregate passing 0.075 mm sieve	+ 1%
Bitumen Binder	+ 0.2%
Temperature of mixing and placing	+ 10° C

14. samples of bituminous paving course mixes shall be taken from the mixing plant and/or behind the paver prior to compaction, as decided by the Engineer, to check compliance with the approved job mix requirements.
15. density of the compacted mixes shall be related to the daily Marshall density which shall be determined by making four standard Marshall specimens from samples of the mix taken from the mixing plant or paver. The density of each sample shall be determined and compared with the mean value. Any individual result which varies from the mean by more than 0.015 g/cc shall be rejected. Marshall tests shall be repeated on a daily basis to establish the daily Marshall density for that particular day's production. Daily Marshall density shall not vary from the job mix design density by more than plus or minus one percent.
16. assistance of the Engineer in the preparation of the job standard mix in no way relieves the Contractor of the responsibility of producing a bituminous mix meeting the requirements of the Specifications.

E. Equipment for bituminous paving operations shall comply with the following:

1. method statement and equipment list shall be according to the type and number outlined in the Contractor's detailed programme of work, as approved by the Engineer,
2. trucks used for hauling bituminous mix shall have tight, clean, smooth metal beds which have been thinly coated with a minimal amount of paraffin oil, lime solution, or other approved material to prevent the mix from adhering to the beds,
3. when required by the Engineer, each vehicle shall be equipped with a canvas cover or other suitable material of such size as to protect the mix from the weather,
4. rolling equipment shall be self-propelled and wheels on the rollers shall be equipped with adjustable scrapers. Rollers shall have water tanks and sprinkling apparatus, which shall be used to keep the wheel wet and prevent the surface material from sticking. Rollers shall be of the steel-wheel and pneumatic tyre type; shall be in good condition; shall be capable of reversing without backlash

and shall be operated at speeds slow enough to avoid displacement of the bituminous mix. The number and weight of rollers shall be sufficient to compact the mix to the required density while it is still in a workable condition. Use of equipment, which results in excessive crushing of the aggregate, will not be permitted. A minimum of three rollers, two steel-wheel and one pneumatic-tyre type, shall be used with each spreading operation for each lane.

5. the Contractor shall provide adequate back-up equipment for use in the event of mechanical failure, all to the satisfaction of the Engineer
- F. Heating of the bitumen binder for mixing and compacting shall be in accordance with ASTM D1559.
- G. Preparation of Mineral Aggregate for Bituminous Mix
1. Coarse and fine aggregate shall be stored at the asphalt plant in such a manner that the separate stockpiles will not become intermixed. Stockpiles shall be of sufficient size to provide a minimum quantity of one week's continuous production of asphalt mix. Aggregates brought to the asphalt plant to supplement stocks should be tested and approved prior to placing in the existing approved stockpiles.
 2. Cold bins shall be calibrated with the materials to be used and the settings shall be such as to produce a combined gradation in accordance with the job mix formula. Proportioning shall be such that surpluses and shortages in the hot bins will not cause breaks in the continuous operation. All the above shall be as approved by the Engineer.
 3. Materials shall be thoroughly dried and heated so that their temperature is within 8°C of the temperature needed to satisfy the viscosity requirements of the asphalt cement. The moisture content of the heated and dried materials shall not exceed 0.5 percent. The quantity of materials fed through the drier shall in all cases be held to an amount which can be thoroughly dried and heated within the limits specified.
 4. Immediately after heating, the aggregates shall be screened into at least five sizes and conveyed into separate bins ready for batching and mixing with bituminous materials. When the aggregates supplied are of such size and grading that separating into five bins is impractical, the number of required separations may be reduced to four or to three with the approval of the Engineer.
 5. Efficiency of the screening operations shall be sufficient to produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates which are reasonably uniform and result in the production of a mix complying with the limits specified for the aggregate gradation.

H. Preparation of Bituminous Mix

1. Dried aggregate as specified and prepared as prescribed above shall be combined in the plant conforming to ASTM D 995-88 in the approved proportions. Bitumen binder shall be introduced into the mix in the proportion specified by the job-mix formula.
2. Initial mixing time will be designated by the Engineer. Mixing time may be increased by the Engineer if additional time is necessary to obtain a homogeneous mix and satisfactory coating.
3. Batch plants, timing shall begin at the start of the introduction of the bitumen into the pugmill.
4. Length of mixing time for continuous plants will be determined by the following formula or other approved methods:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead load capacity in Kg}}{\text{Pugmill output in Kg/second}}$$

5. Temperature of the aggregate immediately prior to mixing shall be within + 8° C of the temperature of the bitumen binder. The temperature of the aggregate and asphalt prior to mixing shall be approximately that of the completed mix as defined in the job mix formula approved by the Engineer. Mix temperature shall be within the limits set out in the job mix formula when emptied from the mixer.

I. Surface preparation

1. When the Bituminous Mix is placed on a prepared road-base and whether or not a prime coat is designated on the Drawings, the Granular Road-base shall be even and firm and within the construction tolerances specified for the road-base to the satisfaction of the Engineer.
2. When the paving layer is constructed 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. Exposed sub-grade and a sufficient width of the shoulder adjacent to the edge of the existing surface to receive the new bituminous mix shall be shaped, bladed, compacted and broomed and primed to provide a uniform firm sub-grade for the new surface course.
3. Existing bituminous surface, base, or sub-grade shall be removed if broken, shattered, or unstable. Areas shall be excavated to a depth as directed by the Engineer, and refilled with the bituminous mix according to the Specifications.
4. Prior to the placing of the mix, when designated on the Drawings or directed by the Engineer, a prime coat or tack coat shall be applied to the road-base or surface in accordance with the Specification for prime coat or tack coat.

J. Placing of the mix.

1. All bituminous mixes shall be introduced to the paver at a temperature not less than 135° C and not more than 163° C. Mixes outside this temperature range shall be discarded.
2. Bituminous mix shall be spread and finished to crown and grade by automatically controlled bituminous paver. Bituminous mix may be spread and finished by hand methods only where machine methods are impractical as determined by the Engineer. The paver shall lay the bituminous mix without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture, free from hollows, transverse corrugations and other irregularities. The paver shall be operated at a speed which will give the best results for the type of paver being used and which co-ordinates satisfactorily with the rate of delivery of the mix to the paver, to provide a uniform rate of placement without intermittent operations of the paver.
3. The mix shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mix during daylight hours.
4. Longitudinal joints in successive layers shall be offset not less than 150 mm. Width of surface or top course placements shall conform to traffic lane edges as shown on the Drawings.
5. Leading half of half roadway paving shall not get ahead of the trailing half of the pavement by more than one average full-day of paving. In no case, shall the leading half be more than 0.5 km ahead of the trailing half without the written permission of the Engineer. If the Contractor fails to comply with this

requirement, the Engineer may suspend paving on the leading half until such time, as the Contractor shall pave the trailing half to a point approximately even with the leading half.

6. Unless otherwise directed by the Engineer, where successive layers are to be placed, the surface of the existing layer shall be swept clean with a power broom, or by other means as approved by the Engineer, and a tack coat applied. Tack coat may not be required where delay between courses laying is less than 48 hours. The surface shall be fresh and clean at the discretion of the Engineer.
7. Asphaltic concrete mixes, except levelling courses shall be laid at an uncompacted thickness such that, after rolling the thickness of the compacted layer shall be:

	Minimum	Maximum
Base Course	60 mm	100 mm
Wearing Course	30 mm	60 mm

8. DBM thickness shall be as specified in Tables 9 & 10.
9. Maximum thickness for layers may be increased slightly when much increase is more adaptable to total pavement thickness and when in the opinion of the Engineer it is not detrimental to placement and rolling conditions.
10. The Contractor shall erect and maintain an approved reference string line and operate the paver to conform to the reference string line for the initial layer and/or any other layers as directed. Elevation control point stakes for the first layer of bituminous paving course shall be set at a maximum spacing of 20 m. For subsequent layers, control points shall be set at 10 m maximum spacing.

K. Compaction of Bituminous Layers

1. After spreading and strike off, and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing. Mixture shall be thoroughly and uniformly compacted.
2. Rolling will not be prolonged to an extent that cracks appear.
3. Initial or breakdown rolling shall be done by means of either a tandem power steel roller or three-wheel roller followed by a pneumatic-type roller or as agreed by the Engineer. Rolling shall begin as soon as the mix will bear the roller without undue displacement. Rolling shall be longitudinal, beginning at the low side of the spread of material and proceeding toward the high side, overlapping on successive passes by at least one half the width of the near wheels. Alternate passes of the roller shall be of slightly different lengths.
4. Motion of the roller shall at all times be slow enough to avoid displacement of the mix. To prevent adhesion of the mix to the rollers, the wheels of the rollers shall be kept properly moistened with water, but an excess of water will not be permitted. Under no circumstances shall the use of diesel fuel or any other asphalt stripping agent be used for preventing adhesion of the asphalt to the roller wheels.
5. Final compaction and finish rolling shall be done by means of a tandem power steel roller, unless otherwise directed. When the specified density is not obtained, changes in the size and/or number of rollers shall be made as corrective measures, to satisfy the density requirements.
6. Rollers shall be operated by competent and experienced roller men and shall be kept in operation continuously if necessary, so that all parts of the pavement will receive substantially equal compaction at the time desired. The Engineer will

order the mixing plant to cease operation at any time proper rolling is not being performed

7. Any mix that becomes loose, broken, mixed with foreign material, or which is in any way defective in finish or density, or which does not comply in other respects with the requirements of the Specification shall be removed. Replace with new materials, and finish in accordance with the Specifications.
8. Road density requirements:
 - a. base course - 97% of average Marshall density
 - b. wearing course - 98% of average Marshall density
 - c. densities in excess of 101.8% shall not be permitted.
9. Prior to the commencement of the bituminous paving operations, the Contractor shall construct trial lengths, of at least 30m. Materials used in the trials shall be those approved for use in the bituminous paving courses. Equipment used shall be that according to the Contractor's approved detailed Method Statement and equipment list and the programme of work. The Contractor may proceed with the bituminous paving operations only after the method and procedures established by the compaction trials have been approved by the Engineer. The object of these trials is to determine:
10. adequacy of the Contractor's equipment.
 - a. loose depth measurements necessary to result in the specified compacted layer depths.
 - b. field moisture content.
 - c. relationship between the number of compaction passes and the resulting density of the material.
11. Compaction sampling and testing of bituminous courses
 - a. Density of the mix as placed and compacted on the road shall be determined from cores cut from the compacted courses on the road at locations specified by the Engineer.
 - b. Samples shall be obtained in accordance with ASTM D979 in sets of two from the same location on the road.
 - c. Frequency of testing shall be one set of samples per traffic lane per 300 m per layer or minimum of one set per day for shorter lengths.
 - d. Additional tests to determine limits of area deficient in density, or for recheck.
 - e. Density of these samples will be referred to as "Road Density".
 - f. Contractor shall cut the samples with an approved core drill in the presence of the Engineer.
 - g. Equipment shall be capable of cutting the material without shattering the edges of the specimen.
 - h. Diameter of samples shall be 150 mm for base courses and 100 mm for wearing courses
 - i. All test holes shall be filled and made good with approved material by the Contractor at his expense.

L. Re-rolling of bituminous courses

Should any bituminous course fail to achieve the specified density, at the discretion of the Engineer re-rolling may be allowed subject to the following conditions:

1. densification to be achieved shall be one percent or less,
2. only PTR's to be used weighing no greater than 18 tons,

3. re-rolling to take place within 72 hours from the time of the initial rolling of the asphalt,
4. re-rolling to take place at the time of the day when the asphalt has attained its maximum natural temperature,
5. re-rolling to be applied for a maximum of two hours,
6. re-rolling to be carried out in the presence of the Engineer's representative,
7. section of the works in question shall be cored for density determination immediately after the completion of re-rolling,
8. if after re-testing, the density achieved is 0.5 percent below the specified density, the asphaltic material will be accepted in the works subject to a 20 percent reduction to the billed rates. If, the density is greater than 0.5 percent below the specified density, the asphaltic material shall be removed and new material to the specification laid at the Contractor's cost.

M. L Contact surfaces between the bituminous paving and of kerbing, gutters, manholes, and other appurtenances shall be painted with a thin uniform coating of tack coat as approved by the Engineer prior to paving.

N. Joints in bituminous paving

1. Joints between old and new pavement or between successive day's work shall be made, to ensure thorough and continuous bonding between the two.
2. All construction joints in previously laid material shall be constructed by cutting the material back vertically for its full depth to expose a fresh surface.
3. Before placing the fresh mix against a cut joint or against old pavement, the contact surface shall be sprayed or painted with a thin uniform coat of tack coat.
4. Where a finishing machine is used the longitudinal joint shall be made by overlapping the screed on the previously laid material for a width of at least 30 mm and depositing a sufficient amount of mix so that the joint formed will be smooth and tight.

O. Protection of compacted layer

1. Contractor shall protect all sections of newly compacted pavement from traffic until they have hardened sufficiently to the approval of the Engineer.
2. On heavily trafficked roads a minimum period of 7 days must elapse before the newly compacted pavement is trafficked.

P. Surface tolerance for bituminous courses.

1. At final compaction the finished surfaces of the individual layers shall fall within the following maximum tolerances, measured with a 3 m straight edge laid in any direction.

Base course	6 mm
Wearing course	4 mm
2. Rideability of the finished wearing course shall be checked with a portable laser road surface testing machine. The riding surface shall have an IRI (International Roughness Index) of less than 0.9 m/km.
3. All humps and depressions exceeding the specified tolerance shall be corrected by removing the defective work and shall be replaced with new material as directed by the Engineer at the Contractor's cost.

Q. Core samples

1. Depth of each bituminous paving course shall be measured by cored samples.

2. Contractor shall furnish and operate an approved core drill for cutting samples from the compacted mix on the road.
 3. Equipment shall be capable of cutting the mix without shattering the edges of the specimen or otherwise disturbing the density of the specimen.
 4. Cored sample diameters shall be 150mm for base course and 100mm for wearing course.
 5. Cores extracted for thickness measurement may be used for density determination. Density samples may be used for thickness measurements.
- R. Thickness of the bituminous paving courses shall be determined in accordance with ASTM D3549.
- S. Weather Limitations for Paving Operations
1. Hot bituminous mix shall be placed when:
 - a. Air temperature is 8°C or above.
 - b. Weather is not dusty, foggy or rainy.
 - c. Existing surface is free from moisture.
 2. No paving operations shall be started if rain is imminent.
- T. Minimum test requirements for bituminous courses
1. Bitumen material: One sample shall be tested for penetration and Ring ball test for every 80 Mg or part thereof.
 2. Aggregate:
 - a. One sample for each stockpile every 2,000 m³ of part thereof.
 - b. Perform all the required tests
 3. Bituminous mix:
 - a. One sample of mix shall be obtained from at least every 300 Mg or part thereof.

Tests	Method
Bitumen content	ASTM D2172
Gradin	ASTM C117 & C136
Density	ASTM D1188/D2726
Stability	ASTM D1559

 - b. Loss of Marshall stability shall be tested for at least every 7,000 Mg.
- U. Prime coat shall be applied at a rate of not less than 0.7 l/m² and not more than 1.5 l/m². The exact rate of application, which may be varied to suit field conditions, will be determined by the Engineer following trials to be carried out by the Contractor. Surface to be prime coated shall be uniformly smooth and firm and true to the grades and cross sections shown on the Drawings within specified tolerances. Prime coat shall not be placed on a soft, uneven base. Any holes, depressions or irregularities shall be repaired by the removal of loose and unsuitable material. Replace with suitable material compacted to produce a dense, even surface of uniform texture. When required, the surface to be primed shall be lightly bladed and compacted. The Engineer may instruct a light application of water to facilitate penetration. Priming will not be permitted when the surface is wet. Prime coat shall not be applied when the ambient temperature is less than 13° C or during rain, fog, dust storms or other unsuitable weather. Application temperature for MC-70 liquid asphalt shall be between 50°C and 80°C as approved by the Engineer. It shall be applied to one lane of the carriageway width at a time. When applied in two or more lanes there shall be a slight overlap along adjoining edges. Overlapping will not be permitted at transverse joints. Thick paper shall be used to

protect the previous application. Traffic shall be kept off the prime coat until it has penetrated the sub-grade or road-base and fully cured and it shall be left undistributed for a period of 48 hours or as otherwise directed by the Engineer. The Contractor shall furnish and spread at his cost sufficient clean fine sand, of an approved quality, to blot up areas which show an excess of prime coat. Primed surface shall be maintained in a good, clean condition at all times until the next course is placed. Any surface irregularities or holes in the primed surface, however caused, shall be repaired and corrected to the Engineer's satisfaction.

- V. The tack coat shall be applied in quantities of not less than 0.3 l/m² and not more than 0.6 l/m². Immediately before applying the tack coat, all loose material, dirt, clay or other objectionable material, shall be removed from the surface with a power broom or blower supplemented with hand brooms, as directed by the Engineer. After the cleaning operation, and prior to the application of the tack coat, an inspection of the area to be coated will be made by the Engineer. Application temperature for the tack shall be between 10° C and 60° C as directed by the Engineer. Tack coat shall not be applied when the ambient temperature is less than 13° C or during rain, fog or other unsuitable weather. After application, the surface shall be allowed to dry to the proper condition of tackiness to receive the following pavement course. The tack coat shall be applied only so far in advance to pavement courses to obtain the proper condition of tackiness. The Contractor shall protect the tack coat from damage during this period. If the completed tack coat is damaged by rain or dust, it shall be allowed to dry, cleaned by power broom or blower. If required by the Engineer, an additional light application of tack coat shall be applied. No additional payment shall be made for this work. Where, in the opinion of the Engineer, a tack coat is not necessary, the Contractor shall clear, at his expense the existing surface free of dust and other deleterious material.
- W. A self-powered pressure distributor should be used for applying asphalt mixture. The distributor shall have pneumatic tyres of such width and number that the load produced on the base surface shall not exceed 110 kg/cm of tyre width and shall be so designed and equipped as to distribute the bituminous material uniformly at even heat on variable width of surface at readily determined and controlled rates from 0.2 to 7.5 l/m² with a pressure range of 1.25 kg/m² to 5.2 kg/m². The allowable variation from any specified rate shall not exceed 5 percent. Distributors and booster tanks shall be so maintained at all times that no dripping of bituminous material will occur from any part of the equipment. Distribution equipment shall include:
1. independently operated bitumen pump,
 2. tachometer pressure gauges,
 3. volume measuring devices,
 4. thermometer for reading the temperature of tank contents,
 5. hose attachment for applying bituminous material to spots unavoidably missed by the distributor.
- X. Distributor shall be equipped for circulation and agitation of the bituminous material during the heating process. Equipment for heating shall consist of steam coils and equipment for producing steam, so designed that steam will not be introduced into the material. In the event of storage tanks being used, an armoured thermometer with a range from 10° C to 150° C shall be fixed to the tank so that the temperature of the bituminous material may be determined at all times. Other heating facilities may be used subject to the approval of the Engineer.
- Y. When bituminous materials are being applied, the surface of all structures, wheel guards, guard rail, kerbs and gutters, and other roadway appurtenances shall be protected in an approved manner to prevent them from being splattered with bituminous

material or marred by equipment operation. In the event that any appurtenances become splattered or marred, the Contractor shall at his own expense, remove all traces of bituminous materials using approved solvents. Repair all damage, and leave the appurtenances in an approved condition.

3.09 Application of Traffic Markings

- A. The Contractor shall layout the work in accordance with the Drawings furnished or as directed by the Engineer. The layout shall include all necessary painting operations to place and/or replace the pavement marking in accordance with the Drawings or instructions of the Engineer.
- B. Longitudinal lines shall be reasonably straight and shall not deviate more than 50 mm in 100 metres. STOP, crosswalk, arrows and parking space lines shall not deviate from the plans more than 2 percent. Pavement markings outside the above tolerances shall be removed or painted out and reinstated at the expense of the Contractor.
- C. Application shall be by mobile sprayer, either hand propelled or self-propelled.
- D. Road surface shall be dry, and free of loose, detritus, mud, or other extraneous matter. Where old paint or thermoplastic material are present, the manufacturer shall be consulted as to whether or not the surface is suitable.
- E. A tack coat shall not be necessary when the thermoplastic is applied to carriageways. Where it is considered necessary to use a tack coat, this shall be rubberized type recommend by the manufacturers of the thermoplastic material.
- F. In addition to the Balottini included in the mix, an additional quantity of glass beads shall be sprayed on to the hot thermoplastic line at the time of application at a rate of application of about 0.5 kg/m².
- G. Thermoplastic material shall be applied in intermittent or continuous lines of thickness 1.2 + 0.3 mm. For special lettering, arrows or symbols the material shall be applied by hand methods. Finished lines shall be free from raggedness at all edges and be true in place with the road surface. Upper surface shall be level, uniform and free from streaks, blisters, lumps and other defects. Application of thermoplastic material to new pavement construction shall be preceded by wire brushing to remove bitumen rich surface mortar. Sufficient compatible mineral oil plasticisers should be incorporated in the thermoplastic material to reduce levels of early shrinkage in the material and subsequent cracking of the asphaltic pavement structure.
- H. Pavement marking shall be protected from marring by traffic as directed by the Engineer with rubber or plastic traffic cones. Traffic cones shall be placed on the line at the time the paint is applied and shall remain until the paint has dried, or in accordance with the directions of the Engineer. Traffic cones shall be collected by a follow-up vehicle and crew. During painting operation, one large working sign with the marking "TRAFFIC STRIPPING" shall be placed as the beginning of each operation. The Engineer may direct that other safety signs be placed at various locations to guide or warn traffic regarding the operation.
- I. The Engineer may direct that the strips be broken into segments, with unpainted gaps between. Broken lines shall be 150 mm wide and have painted segment length of 2 m, with 5 m gaps.
- J. The Engineer may specify transverse lines 200 mm or 300 mm wide for stop lines, crosswalk lines or parking staff lines. These lines must receive special attention in both application and protection from marring by traffic.

- K. Painted traffic arrows or symbols may be specified by the Engineer at designated locations. Details of these arrows or symbols are shown on the drawings. Total area for the painted arrow or symbol will not exceed 3 m².
- L. Painting of kerb stones shall be with alternating bands of black and reflectorised yellow paints. The length of each band and the portion of kerb to be painted are shown on the Drawings or as instructed by the Engineer.

3.10 Application of Road Marking Paint

- A. Paint shall be applied at a covering rate recommended by the manufacturer and approved by the Engineer.
- B. Where markings are to be reflecterised with ballotini it shall be sprayed uniformly on to the wet paint film at the rate of 400 to 500 g/m². Ballotini shall comply with the requirements of BS 3262: Clause 15.
- C. Marking materials shall only be applied to surfaces which are clean and dry. Markings shall be free from raggedness at their edges and shall be uniform and free from streaks. Carriageway lane and edge lines shall be laid by approved mechanical means to a regular alignment.

End of Section 02520

Section 02700: Pipework

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, pipe, fittings, adaptors, valves, appliances, appurtenances and materials and performing all operations in connection with the installation of pipework in accordance with these specifications and drawings.

1.02 Section Includes

- A. The manufacture, factory testing and supply of pipes and appurtenances of different materials for underground and internal pipework for water mains, sewer systems, pressure mains and stormwater drainage.
- B. Laying, jointing, testing, repairing and retesting where necessary, disinfection as necessary, and commissioning of pipework. The Contractor shall provide all labour, materials and equipment necessary for providing the pipes, fittings and jointing materials, transporting to sites, excavation, backfilling and compaction, laying, installing, jointing and testing, disposal of excess excavated materials, and removal of surplus pipes, fittings and jointing materials. The responsibility for the safety and soundness of all material shall rest with the Contractor. The Contractor is advised to carry out any tests, at his cost, needed to satisfy himself regarding the soundness of the pipes, fittings and jointing materials prior to acceptance testing by the Engineer.

1.03 Submittals

- A. Product data, samples and shop drawings shall be submitted in accordance with Section 01300 and shall be as follows:
 - 1. manufacturer's printed brochures and catalogues with relevant information highlighted (or irrelevant information struck out), along with write up of selection criteria;
 - 2. shop drawings including:
 - a. general piping layout drawings to a scale not smaller than 1:500;
 - b. detailed piping layout plans to a scale of 1:200 along with profiles;
 - c. builders work plans to a scale of 1:100 / 1:50 as appropriate;
 - 3. Shop drawings shall be a single set for each facility showing:
 - a. each piping system,
 - b. piping material, class, grade and joint type,
 - c. anchors, thrust blocks, and supports, including hangers, saddles, straps, and other accessories,
 - d. fittings, couplings, joints, and joint harnesses,
 - e. centerline elevations,
 - f. location, size, and type of anchor bolts,
 - g. structure penetrations, including sleeves, sealant and other accessories,
 - h. orientation of valves,

- i. critical clearances,
 - j. insulation,
 - k. pipe coatings,
 - l. valve and control tag numbers,
 - m. miscellaneous details required for complete installation.
- 4. installation details of:
 - a. manholes, chambers, valve chambers, interceptors, sleeves and penetrations etc. to a scale of 1:50, as required;
 - b. manhole covers, drains, and items of similar nature to a scale of 1:10, as required;
- 5. calculations / details to substantiate the shop drawings (ex. Restrain joint);
- 6. shop drawings for valves and fittings;
- 7. designs, including calculations; for piling, shoring of trenches, dewatering systems, cofferdams and similar auxiliary items required for the construction of piping and associated concrete works; where required;
- 8. samples of each type valve and/or manhole covers and step iron, frames, drains etc., for approval and carrying out the required tests;
- 9. samples of gaskets, insulation and sealant systems
- B. The following detailed written procedures shall be provided to supplement the shop drawings:
 - 1. Installation:
 - a. the preparation and making of each type of joint and coupling,
 - b. measures to ensure integrity of interior pipe lining and exterior protective coating at joints and couplings,
 - c. the installation and adjustment of pipe hangers and other supports,
 - d. the procedures to be used in setting, supporting, and anchoring valves,
 - e. the fitting of line pipe to valves for proper coupling.
 - Testing details shall include:
 - a. procedures for adjusting and testing valve assemblies,
 - b. detailed procedure for the testing of systems including, as a minimum:
 - c. equipment to be used, including calibration information, range, and sensitivity,
 - d. qualifications of the person performing the testing,
 - e. details of bulkheads, flanges, caps and the like to isolate systems for testing, procedures to be followed,
 - f. a schedule of times when tests will be performed, including durations,
 - g. procedures for obtaining and disposing of fluid used in testing.
- C. Quality Control Submittals
 - 1. certified copies of reports of required tests, including:
 - a. pipe pressure tests.
 - b. valve tests.
 - c. dielectric joint tests.
 - 2. certificates:
 - a. approval certifications of welders qualifications certified by an approved testing agency including a statement that the welder is experienced and skilled in the materials and methods to be used.

- b. qualifications shall be according to ASME Boiler Code, Section IX.
 - c. qualification shall have been within six months of employment on the Work.
 - d. after approval, the Engineer will return the certificates which will be retained by the Contractor at the Site.
 - e. welds by non-certified individuals will be rejected.
3. pipe support drawings signed and stamped by an engineer.

D. Operation and Maintenance Manuals

- 1. installation data shall include certified equipment drawings with bolt hole patterns and bolt sizing, access door swings and maintenance clearances.
- 2. operation data shall include starting requirements, cautions, and testing.
- 3. maintenance data shall include lubricating schedule, approved lubricants, maintenance and replacement schedules and supplier locations with phone and facsimile numbers.

1.04 Marking

Each length of pipe, fitting and each coupling shall be legibly and permanently marked with the following:

- 1 Name of Employer;
- 2 manufacturing standard;
- 3 serial number;
- 4 pressure rating in bars;
- 5 nominal diameter in mm;
- 6 name or trade mark of manufacturer;
- 7 date of manufacture;
- 8 inspection mark;
- 9 material (indicated i.e. "DI")
- 10 angle of bends in degrees;
- 11 socket penetration lines on spigot ends;
- 12 circular concrete pipes with elliptical reinforcement shall have the letter "T" clearly marked on the inside and outside to indicate the crown of the pipe when laid.

1.05 Infiltration

- A. The Contractor's attention is brought to the stringent requirement for infiltration specified in paragraph 3.04C of this Section for non-pressure pipelines. The Contractor shall be responsible for providing a jointing system that enables the installation and use of the pipeline systems required by the Contract.

1.06 Service Conditions

- A. All water pipeline materials, fittings, valves and components shall be suitable for carrying potable water at temperatures up to 50OC and suitable for storage, installation, use and operation in climatic and soil conditions encountered at the project site.

- B. All other pipes and fittings shall be suitable for carrying sewage at temperatures of up to 40°C with sulfide concentrations up to 65 mg/l and all pipes shall be suitable for immersion in corrosive ground water.

1.07 Basis of Acceptance

- A. Acceptability of the pipes and fittings will be based on the results of tests carried out by an approved independent laboratory at the Contractor's expense and the result of any independent testing carried out by the Employer or his agent. The frequency and type of test required for each pipe material are given in the following sections and certified copies of all records of inspections and test results shall be submitted to the Engineer. All pipeline materials and components, including the protective coatings and jointing materials that will come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discoloration of the water and shall be approved as being suitable for use in water supply schemes. Material that fail to comply with these specifications will be rejected and the Contractor will be required to remove such materials from the site at his expense.

1.08 Utilities

- A. "Utilities" shall mean services ranging from the water, gas and fuel networks and their respective individual metered connections, electrical and telephone networks, poles, pylons, lighting columns and traffic signals, stormwater drainage and sewerage networks as well as roads and other public or private services. The Contractor shall notify all authorities whose services might be affected by the Works regarding his programme. The Contractor shall refer to, and comply with, the current regulations and specifications of the authorities before commencing any works adjacent to other utilities. This requirement will not relieve the Contractor of responsibility for taking every precaution to avoid damage to these utilities and he shall be held responsible for the cost of repair of all damage and other liability claims in accordance with the Conditions of Contract and the Specification.

1.09 Quality Assurance

- B. All pipe, fittings, valves, appurtenances and accessories furnished shall be new and from a current manufacturer. A certificate from the manufacturer stating the materials furnished are new and of a recent manufacture shall be furnished to the Engineer. The Contractor shall also provide the Employer with an affidavit (four copies) from the manufacturer stating that the pipe, fittings, valves, appurtenances and accessories comply with the provisions of these specifications. Certificates that the items comply with the relevant ISO 9000 series for manufacturing processes are also required from the manufacturer.
- C. The Contractor shall also submit evidence that the manufacturer has a long and successful record of operation together with a representative list of overseas consignments where his pipe (of similar diameter) has been placed in operation.

1.10 Packing

- D. All pipes and fittings, valves and specials and all other products shall be packed in such a manner as to prevent damage in ordinary handling and transportation. Each box, bundle or crate shall be legibly marked identifying the contents, and giving the name and address of manufacturer, name of the project, name of employer, and date of dispatch.
- E. Bolts of the same length and size (and their accompanying nuts and washers) shall be packed together in boxes not exceeding 100 kg gross weight. Joint rings, lubricants, sleeving, paints and gaskets shall be packed in boxes and separate packages shall be provided for each size and description of ring or gasket. Each box and package therein shall be clearly labeled stating the manufacturer's name, date of manufacturer, number, size and description of the contents.

1.11 Transporting and Handling

- A. The Contractor shall provide protection, to the approval of the Engineer, for the ends of all pipes and fittings prior to the pipes and fittings leaving the place of manufacturer in order to guard effectively against damage during transit and storage and the ingress of foreign matter inside the pipes and fittings.
- B. In handling pipes and fittings every care shall be taken to avoid distortion, flattening, denting, scouring or other damage. Pipes and fittings shall not be allowed to drop or strike objects and shall be lifted or lowered from one level to another by means of approval equipment only.
- C. When required, pipe and fittings to be lifted by means of a mechanical forklift, or similar equipment, belt slings shall be applied at the correct lifting points along the length of the pipe section, with tackle suitably padded to prevent damage to the coating or lining.
- D. Pipes and fittings that are damaged during transportation, handling or stockpiling shall be satisfactorily repaired. If the damage to any pipe or fitting is serious or beyond the capability of repair in the field as determined by the Engineer, the Contractor shall replace it with new pipe or fitting.

1.12 Storage and Security

- A. All pipes, fittings, valves and appurtenances shall be stored at sites in or around project area approved by the Engineer in accordance with the manufacturer's recommendations until they are incorporated in pipe laying work. The Contractor shall be responsible for providing security including fencing, watching and lighting for the materials at his own cost.
- B. Pipes shall be stockpiled on timber cradles on level ground, in such a manner as will prevent damage to any part of the pipe. During stacking and removal operations, safe access to the top of the stack is essential. Stacking types and the maximum stacking height shall be in accordance with manufacturers' recommendations or comply to BS 8010 Section 2.

- C. Products shall be delivered to site stored and protected under provisions of Section 01600. Pipes and fittings shall be unloaded near the place of installation. Pipes shall be distributed to their point of installation only in such quantities as can be installed in one working day or as allowed by the Engineer.
- D. Vitrified clay pipes and fittings shall be transported in pallets and handled with suitable power driven equipment only.
- E. Jointing materials and operational gear shall be stored under cover. Pipes may be stored in the open, but shall be placed on adequate timber supports to prevent damage. Pipes shall be stored on elevated racks to prevent damage to the seals and shall be protected in a proper manner to prevent deterioration. Plastics and rubber products shall be stored out of direct sunlight. If any pipes or fittings show signs of corrosion or deterioration during storage they shall immediately be treated by the Contractor to arrest deterioration, or to be removed from site as the Engineer directs, all at no extra charge to the Contract.
- F. The Contractor shall submit to the Engineer, and obtain approval before starting the works, (i) the manual for handling, storage, installation, maintenance and repair, (ii) test report on materials to be used for manufacture and (iii) shop drawings giving complete dimensions of all pipes and fittings.

1.13 Material Reconciliation Schedule

- A. Upon completion of the work, the Contractor shall submit to the Engineer a materials reconciliation schedule in respect of the materials supplied. The schedule shall give the following detailed for each item:
 - 1. quantity ordered;
 - 2. quantity delivered;
 - 3. where used;
 - 4. quantity surplus and in good condition;
 - 5. quantity surplus but partially complete cut or damaged and in repairable condition;
 - 6. quantity surplus but damaged beyond repair;
 - 7. quantity missing or lost.
- B. The Contractor shall collect and transport the surplus materials in (4) and (5) to a central location near the job site for inspection by the Engineer's Representative. Materials in group (4) shall be stacked separately. All material shall be in a reasonably clean state and each piece shall be marked with its items number for easy identification.
- C. The Employer, may accept some or all of the surplus materials for maintenance purposes. The Contractor shall load the materials to be taken into stock and transport and off-load them at the Employer's storage yards within 10 km of the job site. The Contractor will be paid for all surplus materials in good condition taken into stock.

Part 2 Products

2.01 Ductile Iron Pipes and Fittings

A. Pipes shall be as follows:

1. spigot and socket pipes shall be used, unless otherwise shown, for buried pipe and shall conform to ISO 2531 with thickness class of K9. The working pressure shall be 16 bar;
2. flanged pipes shall be used, unless otherwise shown, for exposed pipe and shall conform to ISO 2531 with thickness class of K9 or K12;
3. the Contractor shall supply additional materials for maintenance to the Employer as specified herein.

B. Fitting Compatibility

1. The Contractor shall supply the fittings manufactured by the same manufacturer of pipes, using the same kind of material and compatible standards. The Contractor shall also ensure the dimension compatibility of pipes, fittings and couplings to valve flanges.

C. Joint types shall be as shown on the drawings and meet the following requirements.

1. Flexible Joint (Push-On Joints)

- a. Except where flanged joints are required, standard pipes and fittings for pipelines of ductile iron shall be supplied with push-on socket and spigot joints. The material of the joint rings use shall be in accordance with the requirement of BS 2494 type W.
- b. Where pipes and fittings are not available with this type of joint, they shall be supplied with mechanical type flexible joints of the bolted gland type. Glands, bolts, and nuts for mechanical joint shall be of ductile iron having the same mechanical properties as the fittings.

2. Flange Joint

- a. All flanged joints shall be PN 10, 16, or 25 pressure rated and shall be flat faced and shall conform to the requirements of BS 4504 Part 1 (or to ISO 2531 which are compatible with BS 4504 Part 1 for the same nominal diameters)
- b. The flanges of all fittings including Tees shall be integrally cast with the fitting. The flanges of flanged pipes may be welded or integrally cast with the pipe unless otherwise stated.
- c. "Welded" means the flanges should be welded to the pipes at the point of manufacture under factory conditions.
- d. All nuts, bolts and washers to be supplied with flanged joints shall be of galvanized mild steel to the approval of the Engineer. Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt. Protection of all buried bolts, nuts, washers etc. and the joint as a whole shall be covered with Denso paste and primer, Denso mastic, Denso tape or equivalent and PVC or polyethylene outer wrapping as shown in the Drawings.

- e. Gaskets for flanges shall be of the full face type, with dimensions complying with BS 3063, and be manufactured from material complying with BS 2494: Type W.
- f. The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, specially where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures. Isolation valves shall match pipe flanges.

3. Restrained Self Anchoring Joints

The design of restrained joints shall comply with ISO 10804-1 or equivalent.

4. Flexible Coupling and Flange Adapter

- a. Bolted sleeve type couplings, stepped couplings and flange adapters may be used for connecting plain ended steel, ductile iron, grey iron, uPVC and other rigid or semi-rigid pipe materials, subject to approval of each type by the Engineer. Couplings, etc. shall be designed and manufactured in accordance with AWWA C219 "Bolted, Sleeve-type Couplings for Plain-end Pipe" except that elastomeric gaskets shall comply with BS 2494 Type W.

- b. Couplings included in this section will effect a connection between two pipes of either the same pipe materials, or of two different pipe materials, at the same nominal bore. Couplings and flange adapters shall be manufactured from one of the following materials:

Carbon Steel	:	BS EN 10025 Grade Fe 430A, or JIS G3101 SS400, or ASTM A283 grade C
Malleable Cast Iron		BSEN 1562: Grade B35-12, or JIS G5702 FCMB340 or 360, or ASTM A47M grade 32510 or 35018
Ductile Iron		BS 2789 Grade 420/12, or JIS G5502 FCD400, or ASTM A536 65-45-12

- c. Gaskets shall be of elastometric conforming with the requirements of BS 2494 Type W. Gasket shall have a hardness rating of 80IRHD to prevent gasket extrusion at the bottom tolerance of the fitting. All gaskets shall have identification to detail size range, mould number compound and year of manufacture.
- d. Nuts, bolts and tee bolts fasteners shall be manufactured from alloy or carbon steel conforming to BS 970 Part 1 grade 070 M20 or JIS G4051 S20C.
- e. Bolts shall be restrained against rotation by means of "D" shaped necks which will locate in similar "D" shaped holes in the end rings to facilitate single spanner operation. Washers shall be provided to prevent damage to the coating of the fittings.
- f. Centre sleeves, end rings and flange adapters bodies shall be coated with Rilsan Nylon 11 or fusion bonded epoxy coating, to a uniform minimum thickness of 250-300 microns, having been shot blasted and suitably primed prior to application of coating, maintaining the minimum thickness throughout the fitting. Holding points shall be touched in with the appropriate repair coating.
- g. Fasteners shall be electroplated to BS 1706 grade Zn10 or equivalent followed by a suitable primer and then with a coating of Rilsan Nylon 11 to a uniform thickness of 60-120 microns.

- h. Flange adapters for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause. Prior to the commencement of the manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all couplings and flange adapters.
 - i. When harness is specified with coupling or flange adapter, the harnessing shall be provided as recommended by the manufacturer of couplings or flange adapters. Harness joints shall be designed and manufactured to withstand for the pull-out force caused by the internal pressure of 16 bar at the joint.
- D. Length of straight pipes shall conform to the requirements in ISO to be applied. It shall be the sole responsibility of the Contractor to examine the difficulties he is likely to face in transporting, storing, handling and installing long lengths of pipe. In ordering pipe, the Contractor shall consider the possibility of negotiating (pulling) the horizontal and vertical bends. The Contractor shall purchase a sufficient number of straight pipes for his operations, having applicable external diameter to the joints for full length of barrel and be suitable for usage by cutting at sites. Such pipes shall be clearly marked.

E. Coating and Lining

1. External Coating

Pipes and fittings shall have a factory applied external coating of metallic zinc and bitumen paint conforming to ISO 8179, which shall not contain any constituent soluble in water or any ingredient liable to leach in water after drying. The coating shall have good adherence to the pipe and fittings and not scale off. Thickness of the bitumen coating shall not be less than 70 microns and the zinc coating shall have a minimum mass of 130 g/m² of pipe surfaces area. A minimum thickness of the finish coating shall be 70 microns.

2. Internal Lining

Internal surface protection shall be either:

Cement mortar lining, or
Fusion-bonded epoxy coating

a. Cement Mortar Lining

Pipes and fittings shall be internally lined with cement mortar using sulphate resisting cement conforming to BS 4072. The thickness of lining shall be ISO 4179 as follows:

Pipe Nominal Diameter (mm)	Thickness of Lining (mm)	
	Nominal	Minimum
80 to 300	3	2.5
350 to 600	5	4.5
700 to 1200	6	5.5

Inside of socket shall be free of cement mortar lining and shall be coated with the material used for external coating. Internal lining shall be done in accordance with ISO 4179.

b. Fusion-bonded Epoxy Coating

Fusion-bonded epoxy coating for ductile iron pipe and fittings shall conform to JIS G5528, AWWA C213 or equivalent. Material shall consist of a one-component powdered fusion-bonded material composing of epoxy resin, hardener, and fillers. Composition of epoxy resin hardener shall not be less than 55 percent in weight. The standard film thickness shall not be less than

300 microns except for the socket portion where the minimum film thickness shall be 100 microns. The physical properties of coating shall satisfy requirements of JIS 5528, ANSI/AWWA C213 or equivalent. ANSI/AWWA requirements are shown below:

	Item	Requirement	Test Method
i	Impact	Min.1.1 kg-m	AWWA C213
ii	Bendability	Pass	AWWA C213
iii	Appearance	Pass	AWWA C213
iv	Shear adhesion	Min. 210 kgf/sq.cm	ASTM D1002
v	Penetration	Less than 10%	ASTM G 17
vi	Abrasion resistance (5000 cycles-gm loos)	Max. 0.3	ASTM D1044
vii	Cathodic disbondment area	Max. 9.7 sq.cm	ASTM G8
viii	Hot water resistance	Pass	AWWA C213
ix	Water extractable	Max. 0.078 mg/sq.cm	AWWA C213
x	Taste and odour	Pass	AWWA C213

- F. Should the coating fail to satisfy the requirements of the tests or the coating be damaged, the defective or damaged area shall be repaired by using a two-component liquid type epoxy paint.
- G. Pipe components, including the linings and joint materials that will be or may be in contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discoloration of the water and shall be approved by a recognized certifying authority are being suitable for use in potable water supply systems.
- H. Special Protections
1. Pipe and fittings are to be encased in polyethylene sleeving if the requirement is shown in the Drawings. The polyethylene sleeving supplied shall be heavy duty polyethylene sleeving with a thickness of 200 microns, suitable for use in underground locations and shall conform to ISO 8180. Sleeves over successive pipes and at joints between separate sleeves shall be carefully overlapped. The overlap shall be a minimum of 250 mm. The junction shall be carefully taped along the edge of the outer sleeve with an adhesive tape recommended for the purpose by the manufacturer. The Contractor shall furnish all the relevant technical specifications of the sleeving he intends to use in the works to the Engineer for approval, before the sleeves are used. The sleeves supplied shall include necessary adhesive tapes and any other material that may be required for the purpose. Sleeving for a minimum additional 5 percent of the normal pipe length shall be supplied to cover wastage, overlapping and slack.
 2. Tape wrapping shall be provided as additional protection in aggressive soil conditions where the soil resistivity is less than 75 ohm.n or where the occurrence of stray currents is observed or occurrence of corrosion cells due to external metallic structures. Tape wrapping shall be self adhesive bituminous rubber compound providing self sealing joints at over laps and shall be high resistance to cathodic disbondment. Site application shall be conforming to the recommendations of the manufacturer. The Contractor shall furnish all the relevant technical specifications of the tape wrap he intends to use in the works to the Engineer for approval, before use.

I. Shop Testing

Shop testing and inspection of the pipe shall be conducted in the presence of the representative of the Engineer. All the cost for shop witness test shall be borne by the contractor and to be included in pipes supply rates.

2.02 Steel Pipes and Fittings

A. Where specified in the drawings, pipes and fittings to be used in the pump house/room shall be of mid steel conforming to the requirements specified in this section.

B. The following standards are referred to:

BS 4504	Circular Flanges for Pipes, Valves, and Fittings
AWWA C104	Cement Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied
AWWA C205	Cement-Mortar Lining for Steel Water Pipeline
AWWA C208	Dimensions for Steel Water Pipe Fittings
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C602	Cement Mortar Lining of Water Pipelines 4 inch (100 mm) and larger-In Place
AWWA Manual	Steel Pipe Design and Installation MII
ASTM A185	Welded Steel Wire Fabric for concrete Reinforcement
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality
ASTM 307	Carbon Steel Externally Threaded Standard Fasteners
ASTM A570	Hot-rolled Carbon Steel Sheet and Strip, Structural Quality
BS 534	Flanges and Bolting for Pipes, Valves and Fittings
JIS G3101	Rolled Steel for General Structures
JIS G3443	Coated Steel Pipes for Water Service
JIS G3451	Fittings of Coating Steel Pipe for Water Service
JIS G3452	Carbon Steel Pipes for Ordinary Piping
JIS G3457	Arc Welded Carbon Steel Pipes
JWWA A109	Mortar-Lining of Steel Pipes for Water Works

C. Materials

1. Steel pipe and fittings shall conform to AWWA C200 or equivalent standards, subject to the exceptions and supplemental requirements contained in the following sections. The pipe diameters shown on the drawings shall be of the nominal diameters.
2. Steel Cylinder
 - a. For pipe and fittings, cylinder shall be fabricated from hot-rolled carbon steel sheets or plates conforming to either ASTM A283 Grade D, or ASTM A570 Grade 33, or JIS G3101 Class 2 SS 400. The minimum yield point of steel used for fabrication of steel pipe and fittings shall not

be less than 2,300 kg/sq.cm. Steel conforming to JIS G3457 is also acceptable.

b. Fabrication of steel pipe and fittings shall be in accordance with AWWA C200 or BS534. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means.

c. All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and five girth seams per length of pipe. The longitudinal shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe.

d. All steel fittings except bends having a deflection angle less than 5 degrees shall be shop fabricated. Bends having a deflection angle less than 5 degrees may be field fabricated from shop fabricated steel pipe by means of field cutting and welding.

3. Fitting Dimensions

a. All fittings shall be of the same strength, outside diameter and wall thickness as that of pipes, and shall be provided with reinforcing rings and saddles when required in accordance with AWWA Manual M11 to meet the specially high pressure.

b. The dimensions of fittings shall conform to either JIS G3451 or AWWA C208 or equivalent.

4. Joints and Pipe Ends

Pipes and fittings to be jointed by flexible coupling shall have the plain end. Where shown on the drawings, flanged joints shall be provided. Flanges shall be made as seamless forgings or cut and fabricated from steel plates and shall conform to BS4504. Class of flange shall be PN10 unless otherwise specified on the drawings. Material for flanges, bolts and nuts shall be the same steel used for fabrication of steel pipes and fittings. Flanges shall be steel welding neck flanges, and shall be attached to pipes or fittings by means of single butt-weld. All flanges shall be flat faced with bolt holes straddling the vertical axis of the pipes or fittings, and all gaskets shall be of at least 3.0 mm thick asbestos or neoprene, full face with bolt holes correctly sized and spaced. Flanges shall be supplied complete with the required size, quantity and quality bolts, nuts and gaskets.

5. Lining

Steel pipes and fittings shall be lined internally at the pipe manufacturer's works with two coats of bituminous epoxy enamel conforming to AWWA C210 or JWWA K135-1989 with the total uniform dry film thickness of at least 300 microns (0.3 mm).

Fittings larger than 600 mm in diameter shall be wire-fabric reinforced. The wire-fabric shall be 2 x 4 steel wire mesh, 13 gauge each way, and shall conform to the requirements of ASTM A185.

6. Coating

The exterior of pipes and fittings shall be coated with non-breeding type coal tar epoxy at the total uniform dry film thickness of at least 200 microns.

7. Lining and Coating at Pipe Ends

At all pipe and fitting ends, coating and lining shall be extended to the pipe ends.

8. Manufacturer's Mark

Each pipe and fitting shall bear the mark of the manufacturer; the nominal diameter; wall thickness; year of manufacturer; the wordings "Steel Pipe" or "SP", and the owner's name "Ministry of Environment and Energy". The marking shall be conspicuously painted in non-toxic paint on the outside of each pipe and each fitting.

D. Shop Testing

1. Pipe

Shop testing and inspection of the pipe shall be conducted in accordance with AWWA C200 in the presence of the representative of the Engineer. All the cost for shop witness test shall be borne by the contractor and to be included in pipes supply rates. The minimum hydrostatic test pressure for straight pipe shall be determined in accordance with Section 3.4 of AWWA C200 using the design stress equal to 75 percent of the minimum yield point of the steel used. When approved by the Engineer, the hydrostatic test may be replaced by other appropriate non-destructive testing methods such as ultrasonic and/or radiographic testing methods. During pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Pipes that show any leakage under test shall be rewelded at the points of leakage and subjected to further hydrostatic tests until satisfactory results are obtained.

2. Fittings

Upon completion of welding, but before lining and coating, each fitting shall be bulk headed and tested under the same hydrostatic pressure as for the pipe. Provided, however, that if fittings are fabricated from previously tested straight pipe, only those welding seams that were not previously tested in the straight pipe may be tested by means of ultrasonic or radiography method or other methods as approved by the Engineer, with no further hydrostatic test. Any leakage and porous welds which may be revealed by the test shall be chipped out and rewelded and the fitting be retested until satisfactory results are obtained.

E. Mechanical Couplings and Flange Adapters

Couplings for jointing plain-ended pieces shall be of the Dresser Viking Johnson or similar type approved by the Engineer and may be steel or ductile iron at the option of the Contractor. The middle ring (sleeve) and the follower rings (flanges) shall be of such materials and dimensions and that they are not stressed beyond half the yield stress of the material when the pipes connected by them are subjected to the stated hydraulic test pressure. Except where otherwise stated, the middle ring (sleeve) of the coupling shall be provided with a suitable pipe stop (centre register). The joint rings used shall be of Class 'A' natural rubber and the physical properties of the mix shall meet the requirements of BS 2494. Flange adapters for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause. Prior to the commencement of the manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all mechanical couplings and flange adapters. All couplings shall be supplied with a shop coat of quick drying primer approved by the Engineer which is compatible with the materials to be subsequently used for moulding or painting. When harness is specified with coupling or flange adapter, the harnessing shall be provided as recommended by the manufacturer of couplings or flange adapters. Harness joint shall be designed to withstand for the pull-out force caused by the internal pressure of 10 bar at the joint.

2.03 uPVC Pipes and Fittings

- A. Pipes shall conform to **ISO-4422** and shall be installed in accordance with the manufacturer's guidelines. All jointing shall be by socket and spigots with sealing rings

- which shall conform to BS 7874. Solvent welded joints are not permitted. Pipes shall be capable of withstanding ultraviolet degradation and shall incorporate a rodent inhibitor. Pipes shall be furnished in standard laying lengths of 6 m and shall be grey in colour.
- B. Fittings made of uPVC shall conform to BS 4346 and shall be manufactured by heat injection moulding or extrusion machine only. Fittings shall have the same strength as the connecting pipe.
 - C. All joints shall be designed to have the same characteristics and strength as the connecting pipe. Unless otherwise specified;
 - 1. joints for underground pipes and fittings 90 mm and larger shall be push in type using rubber gaskets;
 - 2. joints for underground pipes and bends of 63 mm shall be welded using solvent cement;
 - 3. joints for other underground fittings of 63 mm shall be push in type using rubber gaskets;
 - 4. joints for all exposed pipes, and pipes smaller than 63 mm, shall be welded using solvent cement.
 - D. For push in joints, the pipes shall have an integral socket end and spigot end. The socket shall be designed by the manufacturer. One neoprene ring shall be furnished for each joint. The neoprene ring shall conform to JIS K6353, BS 2494, ASTM F477, or equivalent.
 - E. For welded joints, the pipes shall have an integral socket end designed by the manufacturer. Solvent cement shall conform to **ISO 8588:1987** or BS 4346 and shall be mixed in strict accord with the manufacturer's instructions. Any impurities in the cement shall be cause for rejection. Data on the pot life of the cement shall be approved by the Engineer.
 - F. Flanged joints shall be made using flange adapters.
 - G. Testing of pipes and fittings shall be carried out in accordance with JIS K6741, JIS K6742 or equivalent. Each pipe and fitting shall be tested under an internal hydrostatic pressure of not less than 118 Pa for the duration of 60 seconds. The Contractor shall furnish test certificates of tests carried out for quality control during the manufacture of the pipes in accordance with **ISO-4422** and Appendices A to E of BS 3505:1986 and shall, if required by the Engineer, undertake such additional tests as the Engineer considers necessary.

2.04 Glass Reinforced Plastic Pipe

- A. GRP pipes shall be fabricated in compliance with BS 5480. Resins shall comply with BS 3532, BS 3534 or ASTM D1763. Approved isophthalic, bisphenol, epoxy or vinyl ester resins may be used, glass reinforcement shall be E-glass fibres complying with BS 3396, BS 3496, BS 3691, or BS 3749 or the type known as ECR. If filler aggregates are used, they shall be graded silica sands complying with ASTM C33 of sizes between 0.5 and 3 mm. All pipes shall have a suitably reinforced resin rich layer to give high corrosion, impact and abrasion resistance. The inside of pipes shall have a vinyl ester resin rich layer at least 1.5 mm thick. No reinforcing fibers or extraneous material shall protrude from the inner surface of the pipe wall. The outside of the pipe walls shall have a resin rich layer at least 1 mm thick. Sand may be incorporated into the outside layer. Resins shall be cured to a hardness of not less than 90 percent of the Barcol hardness recommended by the resin manufacturer when measured according to BS 2782: Part IV, method 1001 or ASTM D1583

B. Dimensions and Tolerances

1. The finished dimensions of all pipes, fittings, couplings, specials or other items shall enable their assembly into a complete system required by the Contract, particularly in respect of joint flexibility and watertightness. Incompatible components shall be replaced at no extra cost to the Employer. The dimensions of every pipe will be measured.
2. The manufacturing tolerances for pipe diameter shall be + 1 percent for pipes up to and including 600mm diameter and +0.5 percent for larger sizes. Deviations shall be such that joints are not affected
3. The standard lengths of pipes shall be in accordance with BS 5480 Part 1 unless otherwise specified. The tolerance for special pipes of specified lengths shall be +25 mm.
4. The maximum permissible deviation of the pipe bore from the true straightness when measured at the factory or at site, shall be 0.3 percent of the effective pipe length or 15mm, whichever is smaller

C. Mechanical Properties

1. The stiffness of the pipe when defined as EI/D^3 , where E is the circumferential bending modulus of the pipe wall (N/m²), I the moment of inertia of the pipe wall per unit length (m²/m) and D the nominal pipe diameter, shall be 10kN/m. One pipe in every twenty five of each class and diameter manufactured shall be tested to determine the initial specific stiffness in BS 5480, Part 2 Appendix J.
2. The composition of the wall shall be such that a minimum hoop flexural modulus of 12 GN/sq.m and 15 GN/sq.m shall be achieved over the whole thickness for pipes up to and including 350mm diameter and pipes above 350 mm diameter respectively.
3. Beam strength. The following shall be the minimum values of the initial ultimate resistance to longitudinal tensile force per unit of circumference:

Nominal Diameter (mm)	Initial Ultimate Resistance (N/mm)
above 600 through 1200	200
above 1200 through 2400	250
above 2400 through 4000	300

Longitudinal tensile strengths shall be determined in accordance with ASTM D638 or DIN 53 - 455 and shall be carried out on one pipe in every 100 pipes of each class and diameter manufactured.

4. When subjected to a parallel plate load test in accordance with ASTM D2412 the pipe shall reveal no evidence of crazing, cracking at deflection of 10 percent, and no evidence of structural failure at a deflection of 20 percent. Evidence of compliance with the foregoing requirements shall be provided by carrying out the tests in the presence of the Engineer or his representative.
5. All non-pressure pipes shall be tested to an internal pressure of 1.5 bar for a period of 5 minutes. Any appearance of water on the outside of the pipe shall be deemed to represent failure. All pressure pipes shall be tested to the specified internal pressure.
6. Samples of pipe representative of those to be supplied shall be subjected to the corrosion test detailed in ASTM D3681 in the Engineer's presence if necessary, and evidence of conformance shall be furnished prior to commencement of manufacture. Further regular tests shall be made by the Contractor and the results furnished as a feature of his quality control procedure. Notwithstanding

the requirements of Section 5.1.1 of ASTM D3681, any appearance of blisters, delaminations, wicking or other structural blemishes shall be taken to mean that the pipe has failed and the end point reached.

7. The Barcol hardness test to check resin cure shall be done on every pipe or fitting.
 8. One pipe in every twenty five of each size shall be tested for loss on ignition in accordance with ASTM D2584.
- D. Checks of dimensional accuracy will be carried out by the Engineer or his representative, as required, both at the place of manufacture and at site. Any units found at any time failing to meet specified dimensional criteria or quality criteria or any quality criteria set out hereinafter, shall be destroyed forthwith or indelibly marked as rejected and removed from site. Any pipe which when resting freely on the ground and not subjected to any loads other than its self weight exhibits a deflection, measured along the diameter, of more than 2 percent shall be condemned and treated as described above
- E. The visual inspection criteria for GRP pipes shall be:
1. scratches - not deeper than 0.3 mm and no reinforcing fibers are exposed. Acceptable after repair if greater than 0.3 mm but less than 1 mm.
 2. cracks - no cracks permitted on inside of pipe. Hair cracks on the outside may be permitted with repair if not longer than 200 mm circumferentially or 6mm longitudinally. Impact cracks shall not affect more than 3 percent of surface area.
 3. delaminations - not permitted.
 4. impact or other damage to pipe ends - the end surface of pipe of other unit shall be completely covered with resin and free from cracks, porosity, bubbles, voids, exposed reinforcement or extraneous matter.
 5. protruding fibers - no protruding fibers permitted on internal or jointing surfaces. In any pipe or unit, not more than three areas, each not more than 100 sq. mm in area, will be permitted on the outside.
 6. other protuberances - small globules or resin projections permissible if not more than 25 percent of area is affected. Internal and jointing surfaces shall be completely free of any such flaws. Ridges formed by resin shall not exceed 1.5 mm in depth.
 7. air voids, blisters, bubbles. - not acceptable if greater than 5mm diameter or 1 mm depth. If less than 0.5 percent of internal areas are affected, grinding out and repairing may be permitted.
 8. pitting - not more than 5 percent of the internal or 10 percent of the external surface shall be affected. No individual pit shall be more than 1 mm diameter or 0.5 mm depth.
 9. wrinkles and indentations - not more than 2 mm deep and not more than 3 percent of surface area affected. If not more than 5mm deep and 0.5 percent of surface area is affected, repairing may be permitted.
- F. GRP pipes are made of delicate elastic materials, and require special care in loading, unloading, handing and storing. Nylon lifting straps 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.

2.05 Vitrified Clay (VC) Pipe and Fittings

A. All pipes, fittings, and related accessories used shall conform to EN-295 including its latest amendments, additions, and revisions, or any approved equal standard, and shall be procured from an approved manufacturer.

B. The value of the crushing strength shall not be less than as specified under:

Pipe Dia.(mm)	Crushing Strength (kN/m)
200	60
250	60
300	65
350	70
400	75
450	80
500	80
600	90
700	90
800	90
900	90
1000	90

C. The physical properties of the pipe material shall not be inferior to:

specific weight	22	kN/cu. m.
bending tensile strength	15	N/sq. m.
compressive strength	100 N/sq. m.	
tensile strength	10	N/sq. m.
Mohs hardness	7	
modulus of elasticity	50k	N/sq. mm.
coefficient of thermal expansion $5 \times 10^{-6} / ^\circ\text{K}$		
thermal conductivity	1.0	kcal/h/moC

1. the outer and inner surface on the barrel of pipes and fittings shall be ceramic glazed. The outer surface of the spigot end may remain unglazed for a length equal to the socket depth. The body of pipes and fittings shall be hard and solid and differences in color, if any, shall not affect the quality.
2. joints shall be watertight and resistant to acids, chemicals, and root penetration, and will last for the full lifetime of pipe. It should be easy to assemble and shall not unduly stress the pipe barrel. All the joints in vitrified clay pipes shall be designed to withstand a pressure of at least 8 m head of water. Such joints shall be constructed by introducing sealing elements between socket and spigot pipe barrel gaps. Pipes having size ND 200 and above will have sealing element fixed on both spigot and socket ends. These joints are called K-type joints. The sealing element on the socket shall consist of a rigid compensating material and an elastic sealing and compensating material on the spigot end. Joint material shall be suitable for the environmental conditions in the sewers as defined in these Specifications.
3. testing of materials shall be carried out in the following stages:
 - a. manufacturer shall furnish an understanding that all the pipes and jointing material is manufactured to satisfy all the requirements of BS EN-295 specifications,

- b. all the materials shall be tested by an approved international testing agency before actual shipping of material to site is effected. Frequency of testing shall be as specified in BS EN-295. All test results shall be supplied to Engineer,
 - c. the Employer may elect (at Contractor's cost) to send an engineer to supervise the manufacturing, testing and forwarding processes to ensure strict compliance to these specifications. All the costs of testing of materials and boarding, lodging and air-ticket of the Employer's representative shall be borne by the Contractor. If any material fails in any of the tests stated above or if the Contractor fails to fulfill these requirements, the whole lot of that batch of materials shall be rejected
 - d. after arrival of material at site and before acceptance all pipes and fittings shall be inspected for any visible defects, damage and cracks. Fine cracks can be detected by dusting with talcum powder,
4. dimensions of the pipes and fittings shall be measured as follows:
- a. internal diameter inside the barrel at a distance of about 50 mm from the socket level,
 - b. external diameter of socket outside pipe at the middle of socket,
 - c. external diameter of spigot outside pipe at spigot end,
 - d. the wall thickness shall be measured at several points of the barrel and an average
 - e. taken,
 - f. deviation of the pipe barrel from straightness shall be determined using a straight gauge rod having a length of 0.8 of the pipe length. The rod shall be kept outside or inside the pipe barrel approximately equidistant from spigot end and socket shoulder. Distance at the center of the rod, between the rod and pipe barrel, shall be measured and related to the length of gauge length,
 - g. deviation of pipe barrel from straightness when measured in accordance with Clause 3 of BS EN-295 shall not exceed the values as mentioned below:-
- | DN(mm) | Deviation (mm/m) |
|--------|------------------|
| 6 | 100 & 125 |
| 5 | 150 & 250 |
| 4 | 300 & above |
- h. average internal diameter of pipe shall be such that cross-sectional area of pipe is not reduced more than 3 percent from that considered for design calculations
 - i. length variation shall usually not exceed +4 percent or -1 percent of specified pipe lengths. For length of fittings the same limits shall apply,
5. the following markings shall be stamped on the product before fixing:
- a. BS EN-295
 - b. manufacturer's symbol
 - c. date of manufacture
 - d. nominal size, DN
 - e. type (standard strength/extra strength)
 - f. minimum crushing force (for pipes only)
 - g. the angle in degrees (for bends only)
 - h. inspected by (Name and Mark of Testing Agency)

2.06 Concrete Pipes and Fittings

- A. All reinforced concrete pipe and fittings, except where otherwise specified, shall conform to ASTM C76M except as modified hereunder. All pipes shall be hydrostatically tested. All pipes 250 to 600mm diameter shall be of unreinforced concrete. All pipes 700mm diameter and over shall be of reinforced concrete. All pipes shall be protected with an epoxy coating. Where called for in the Particular Specifications pipes shall be lined with a PVC liner and externally coated with an epoxy coating.
- B. Pipe materials shall be as follows:
 - 1. cement used for manufacturing pipes and fittings shall be sulfate resisting Portland cement conforming to BS 4027 or ASTM C.150 Type V. The minimum cement content shall not be less than 335 kg/m³,
 - 2. aggregates shall conform to the requirements of BS 882. No modification to the grading may be made without the written approval of the Engineer. The Engineer may require proof of satisfactory performance of the concrete manufactured with aggregates with the modified grading. The nominal maximum aggregate size shall be less than 20 mm, the concrete cover to reinforcement or one quarter of the pipe wall thickness.
 - 3. reinforcement shall conform to BS 4449 or BS 4483 as appropriate. Transverse reinforcement shall be located in a circular, or helical arrangement, and shall be fixed in such a manner as to prevent displacement during concreting. Reinforcement steel shall be accurately placed in the concrete wall. The placement of all steel shall not vary from the position in the pipe wall shown on the drawings by more than plus or minus 6mm from the nominal position. In no case shall the cover to the reinforcement be less than 25mm. Other permissible variations shall be in accordance with ASTM C76M.
 - 4. admixture shall be used only with the written permission of the Engineer. The methods of use and the quantities of admixtures used shall be subject to the approval of the Engineer. Admixtures containing calcium chloride will not be permitted. The chloride ion content of admixtures used in reinforced pipes using sulphate resisting cement, shall not exceed 2 percent by mass of the admixture, or 0.03 percent by mass of the cement,
 - 5. water shall be clean and free from harmful matter. The water/cement ratio shall not exceed 0.49.
- C. Unless stated otherwise, concrete shall be placed in the form by means of vertical casting. Storage of concrete materials, mixing, curing and testing of concrete shall be in accordance with the appropriate clauses of Section 03300. Any deviation from these clauses shall be made only with the written approval of the Engineer.
- D. Unless stated otherwise crushing strengths of pipes shall not be less than those specified in ASTM C76M for the respective classes of pipes shown on the drawings.
- E. Reinforced concrete pipes shall have a minimum nominal length of 2.5 m except as otherwise specified, or required for special purposes such as curves, closures or built in pipes. Unless otherwise detailed the maximum nominal length shall be 6m.

- F. The pipe joints shall be supplied with flexible joints of the spigot and socket type. Joints shall comply with ASTM C361M and be tested to a hydrostatic pressure equivalent to 10 m head of water to the soffit of the pipe. Acceptance of concrete pipes is dependent upon the Contractor demonstrating that the joints are capable of withstanding an external pressure equivalent to 10 m head of water without leaking in both the straight and deflected positions. The demonstration shall be repeated at agreed intervals during the supply of the pipes. The sealing ring shall be confined in a contained groove on the spigot face of each pipe section to properly position and confine the rubber gaskets in the annular space. Each joint shall contain a neoprene ring gasket which shall be the sole element depended upon for watertightness of the joint. The gasket shall be of circular cross sections unless otherwise approved by the Engineer. The length and cross-sectional diameter of the gasket, the annular space provided for the gasket, and all other joint details shall be such as to produce a watertight joint which shall not leak when pulled 13mm over and above the initial jointing allowance. The initial jointing allowance is the gap between the spigot and the shoulder of the socket measured parallel to the center of the pipeline and shall not be less than 6mm or greater than 12mm. The joints shall be capable of unsymmetrical closure in any direction with not more than 25mm opening at the joint and shall maintain watertightness at any deflected position within this specified range
- G. Gasket stock shall comply with ASTM C361M and shall be a synthetic rubber compound in which the elastomer is neoprene, exclusively. Solid compound shall contain not less than 50 percent by volume of neoprene and shall contain no reclaimed rubber or any deleterious substances. The stock shall be extruded or molded and cured in such a manner that any cross-section shall be dense, homogeneous and free from porosity, blisters, pitting and other imperfections. The stock shall be extruded or molded with smooth surfaces to the specified size within a tolerance of +6 percent on any dimension, measured at any cross-section
- H. Concrete pipes shall be substantially free from fracture, large or deep cracks, and surface roughness. The planes of the ends of the pipe shall be perpendicular to their longitudinal axis.
- I. Inspection procedures and test shall be carried out in accordance with BS 5911. All pipes will be hydrostatically tested in accordance with ASTM C443. Pipes shall be subject to rejection on account of failure to conform to any of the specification requirements or on account of any of the following:
1. failure to pass hydrostatic test,
 2. failure of the longitudinal concrete surfaces of joints to meet the dimensional tolerances indicated on the shop drawings,
 3. fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joint exist in more than 10 percent of the pipe inspected, however, the defective pipes shall be rejected,
 4. defects that indicate defective mixing and molding,
 5. surface defects indicating honeycomb or open texture,
 6. spalls deeper than one half the depth of the joint or extending more than 100 mm around the circumference or spalls smaller than one half the depth of the joint or less than 100mm around the circumference exist in more than ten percent of the pipe,
 7. exposed reinforcement which indicates that the reinforcement is misplaced
- J. All exterior surfaces that will be exposed after joining of the reinforced concrete pipe shall be coated by the pipe manufacturer with a minimum 650 microns dry thickness of

a heavy duty, 100 percent solid coal-tar epoxy durable abrasion resistant and especially designed for production line application on moist concrete as specified in Division 9.

2.07 Blue Epoxy Protective Coating

The non toxic, high build, solvent free, chemical and corrosion resistant epoxy resin based coating shall be approved for contact with drinking water by NWC/WRC (UK) or similar authority. The necessary certificate is to be provided. The coating shall be smooth and glossy, colour code RAL 5015 and shall be suitable for application to valves, water pipes etc.

2.08 Polyethylene (PE), Fittings, Specials and Accessories

A. Scope

This specification covers polyethylene pipes and associated fittings for the use of cold drinking water.

B. The following standards are referred to

ISO 44	Polyethylene (PE) pipes for water supply specifications.
EN12201-1	Plastic piping System for Water Supply –Polyethylene (PE) Part 1- General
EN12201-2	Part 2- Pipes
EN12201-3	Part 3- Fittings
EN12201-4	Part 4- Valves
EN12201-5	Part 5- Fitness for purpose of the system
BS 2782-11	Thermoplastics pipes for the conveyance of fluids
Method 1121B:1997	Nominal outside diameters and nominal pressures – Metric series.
BS ISO 4065:1996	Thermoplastic pipes universal wall thickness table.
BS ISO 11922-1:1997	Thermoplastic pipe for conveyance of fluids - Dimensions and tolerances.
WIS 4-24-01	Specification for mechanical fittings and joints including flanges for polyethylene pipes for the conveyance of cold potable water for tee. Size range 90-1000 inclusive made to metal or plastics or a combination of both.
WIS-4-32-03-1987	Specification for blue polyethylene pressure pipe for cold potable water (nominal sizes 90-1000 for underground or protected use).
WIS-4-32-08 issue 2-1994	Specification for site fusion of PE 80 and PE 100 pipe & fittings .
WIS 4-32-13-1993	Specification for blue higher performance polyethylene (HD PE/PE 100) pressure pipes (nominal sizes 90-1000) for underground or protected use for the conveyance of water intended for human consumption.
WIS 4-32-15-1995	Specification for PE 80 and PE 100 spigot fittings and for drawn bends nominal sizes up to and including 1000 mm.
DIN 8075-1999	Polyethylene (PE)pipes General Quality Requirements and Testing .
DIN 8074-1999	Polyethylene (PE) Pipes-dimension

ISO 12162:1995	Thermoplastics material for pipes and fittings for pressure applications- clarifications- clarification and designation overall service (design-co-efficient).
DIN 16963 1-15 series	Pipes joints and elements for high Density Polyethylene (HDPE) pressure pipe lines.
BS6572:1985	Specification for blue polyethylene pipes up to nominal size 63 for below ground use for portable water.
WIS-4-32-12-1995	Specification for PE80 and PE100 electrofusion fittings for nominal sizes up to and including 630mm.

C. Definitions

The definitions given in the relevant standards which are referred to in the specification, shall apply for the terms used in this specification.

D. Polyethylene Pipes

Polyethylene pipes shall be flexible and in pipe form or coil form complying with standards given in the reference standards in the document.

Pipes shall be manufactured by using polyethylene as main raw material. During the manufacturing process. the pipes shall be marked with pertinent product and process information at approximately 1m intervals along the pipe.

At least following information to be included in addition to marking mentioned in Clause 7 of Specification –General.

- Manufacturer's identification mark.
- The dimensions (nominal outside diameter and nominal wall thickness)
- Reference Standard number (Specification number) or manufacturing standard.
- Pressure rating at relevant temperature
- The designation of the pipe material (i.e. PE-Value).
- The word "WATER" in letter size as given in Table –1 marking.
- Standard dimension ratio (SDR)
- The identification mark; "Ministry of Environment and Energy" in letter size as given in Table 1-marking 10mm.
- Third party certification mark by the Inspection Agency approved by the Engineer.
- Production period (date of manufacturer)

Pipes shall be produced by manufacturers who operate a quality assurance scheme to ISO 9002/9001. The manufacturer shall submit a certified copy of quality assurance certificate.

In the event of supplying the pipes to a different standard which is not in the standard list given. Contractor shall provide all information related to following for the Engineer's consideration for his approval.

- Conformity of particular product to a specification mentioned above
- Relationship between the offered material specification and the ISO 4427 in the form of product catalogues and their comparison as given below

- Manufacturers catalogues should be submitted with clear marking on corresponding comparisons to show the offered material is superior or equivalent to the specifications given herein.

ISO 4427	
ISO Table No.	Corresponding data in the Offered specification
Outside Diameters and Tolerance for PE plastic Tubing.	3,4,5,6
Wall Thickness and Tolerance for PE Plastic Tubing	3,4,5,6
Sustained water pressure Test Conditions for PE Plastic Tubing.	8
Burst Pressure Requirements for Water at 20° C (68° F) for PE Plastic Tubing.	8

Note:

Temperature - Temperature correction to be carried out and proper type of pipe shall be provided to suit the temperature given in the document.

E. Fittings

Polyethylene fittings shall be manufactured by injection moulding complying with the standards given in the reference standards in the document.

Following information to be marked on the fittings.

- Manufacturer's Identification
- The dimensions (nominal outside diameter and nominal wall thickness).
- In case of a bend, bending angle and incase of unequal tee branch line size and main line size.
- Designation of pipe material (ie . PE value)
- Standard number (specification number)
- Pressure rating at relevant temperature
- Standard dimension ratio (SDR)
- The word "Water" in letter size as given in Table-1 marking.
- The identification mark "Ministry of Environment and Energy" in letter size as given in Table –1 marking
- Certification by the Inspection Agency approved by the Engineer.
- Fusion time (Seconds)
- Cooling time (minutes)
- System voltage
- Production period (date of manufacturer).

F. Compression Fittings for PE pipes

Couplings, flange adaptors etc shall be compatible with the pipes specified in the above section 8.1.3.4

G. Service Conditions

Usage – In under ground service connections for domestic water supply.

Water temperature	30C°
Water PH range from	6.5 – 7.9

H. Testing

Testing shall be carried out fully in accordance with the requirements of ISO 4427 and DIN 8075- 1999 or equivalent standard acceptable to the purchaser

I. Dimensions of Pipes and Fittings

Dimension of standard pipes shall conform to the following standards.

ISO 4427	-PE pipes for water supply specifications
BS 2782	-for outside diameter & nominal pressures
II: methods II 21B 1997	
ISO 161-1	
BS ISO 4065 – 1996	-Thermoplastic pipes – universal wall thickness table
ISO 11922–1:1997	-Thermoplastic pipes for the conveyance of fluid Dimensions & tolerances – Part I metric series
DIN 8074 August 1999	Polyethylene pipes dimensions

Dimensions of fittings shall conform to the following standards.

WIS – 4 – 32 – 15	-Specifications for PE 80 and PE 100 Spigot fittings and drawn 1995 bends for nominal sizes up to and including 1000mm
DIN 16963 1-15 series	-Pipes joints and elements for high Density Polyethylene (HDPE) pressure pipelines. Standard lengths of a straight pipe shall be 12 m.

J. Method of manufacture of pipes & fittings

1. Manufacture

- a. Polyethylene are manufactured by various process and are blended with anti-oxidants, pigments and UV stabilizers to ensure the material is suitable for use in the water industry. Amongst other factors, the range and quantities of co-monomers used can result in substantially different basic properties, e.g. melt flow rate, density, creep resistance etc.
- b. The resulting compound is normally delivered to the manufacture in the form of granules and the PE pipes are produced by an extrusion process.
- c. PE fittings shall be manufactured by injection moulding.
- d. Following the quality control inspection and testing, caps or plugs are to be provided to protect the jointing surfaces during transportation

and storage. The finished and protected pipes are then carefully packed into manageable units (bundles or coils) prepared for shipments.

- e. The manufacturing process of the PE pipe should be closely observed and accurate contract of both materials and plant to be exercised.

2. Production Quality Control

- a. The manufacture of PE pipe is a continuous processing which necessitates strict and accurate control of both materials and plant to achieve the required quality. A range of quality control tests pressures in the relevant standards should be applied within the scope of a quality assurance in accordance with BS 5750: Part II.

- b. These control procedures shall include:

- Quality testing of raw materials, i.e. base compound.
- Checks on the uniformity and consistency of the granules
- Control of processing parameters in terms of temperature, pressure, flow rates, haul off speed and energy input
- Visual inspection of the pipes to check general appearance, dimensional compliance and any indication of inclusions or processing flaws in pipe barrels and jointing ends,
- Production short term tests, to identify any variations in the plant function.

- c. Essential short-term quality control tests and procedures are described in the relevant Water Industry Specifications include the following

- Appearance and surface condition
- Dimensions
- Thermal stability
- Elongation at break
- Hydrostatic pressure test at 800 C
- Short term pressure test

3. Product Type Tests

- a. In addition to 'production quality control' tests, there are a number of important longer-term 'Type Tests' that must be undertaken to demonstrate the long-term performance of the pipe. These tests are also required whenever there is any change in such parameters as formulation, size, classification or processing technique.

- b. These 'Type Tests' are again detailed in the relevant specifications and include the following:

- Effect on water quality
- Resistance to weathering
- Long term hydrostatic pressure testing
- Resistance to fracture on impact tensile strength,
- Elongation and weld test

- c. Perhaps the most fundamental Type Test is the long term hydrostatic test which is a standard means of predicting the long-term performance of the pipe. In this test, samples are subjected different circumferential (hoop) stresses by pressurization and the subsequent time to pressure is

recorded. The individual results are plotted as a log stress versus log time graph. They are then subjected to regression analysis to obtain an extrapolated 50 year stress level.

- d. It is worth bearing in mind that the above requirements for long-term performance levels are minimum values and manufacturers usually ensure that their products can comfortably meet these standards, i.e. the pipes have an additional factor of safety built into them to cover any manufacturing variables.

K. Classification

The terms PE 80 and PE 100 are a classification developed in line with a decision taken at CEN/TC 155, the European Technical Committee drafting plastics piping system standards for polyethylene products for water supply.

According to this classification, as detailed in ISO/DIN 12162 PE 80 material has a Minimum Required Strength (MRS) value of 8 Mpa and PE 100 has a MRS value of 10 Mpa. The international Standards Organization (ISO) technical procedure ISO TR 9080 (3) identifies these MRS values derived from the 50 year extrapolated 97.5% Lower Confidence Limit (LCL) failure stress.

Table3 - Size Ranges, Current Pressure Ratings and
Appropriate UK specifications

Material type	Size range available	Maximum rated working pressure (bar)		Colour	Use	UK Specification
PE 80	20 – 63	SDR 11	12 bar	Blue	Below ground	BS 6572 (6)
	90 – 180	SDR 11	12 bar	Blue	Below ground	BS 4-32-03 (7)
	90 – 180	SDR 17.6	7.5 bar	Blue	Below ground	BS 4-32-03(7)
	250 – 1000*	SDR 11	10 bar	Blue	Below ground	BS 4-32-03 (7)
	250 – 1000*	SDR 17.6	6 bar	Blue	Below ground	BS 4-32-03 (7)
	20 – 63	SDR 11	12 bar	Black	Above ground	BS 6730
	90 – 180	SDR 11	12 bar	Black	Above ground	WIS 4-32-09 (10)
	90 – 180	SDR 17.6	7.5 bar	Black	Above ground	WIS 4-32-09 (10)
	250 – 1000*	SDR 11	10 bar	Black	Above ground	WIS 4-32-09 (10)
	250 – 1000*	SDR 17.6	6 bar	Black	Above ground	WIS 4-32-09 (10)
PE 100	90 - 1000	SDR 11	16 bar	Dark Blue	Below ground	WIS 4-32-13 (4)

Material type	Size range available	Maximum rated working pressure (bar)		Colour	Use	UK Specification
		SDR 17.6	10 bar	Dark Blue	Below ground	WIS 4-32-13 (4)
		SDR 26	6 bar	Dark Blue	Below ground	WIS 4-32-13 (4)
		SDR 33	5 bar	Dark Blue	Below ground	WIS 4-32-13 (4)
<p>* Note : PE 100 of SDR 26 and 33 are particularly used for slip lining purposes where the pipe is structurally supported. Rapid Crack Propagation (RCP) - It is theoretically possible for rapid long line fracture of butt welded PE pipes to occur in extremely adverse conditions and it has been produced in air filled pipes under pressure.</p>						

The Contractor shall also submit full details of the manufacturing process he intends to use with his supply.

L. Joint Rings

The physical properties of elastometric joint rings shall comply with Table 3 of BS 2494: 1990. The joint rings shall also comply with the relevant provisions in BS 2494 for effects on water quality and resistance to microbiological deterioration.

The material of joint rings shall be of EPDM/SBR and shall be dual hardness punching type with 76-84 IRHD at the heel of the ring and 46-55 IRHD at the bulb of the ring.

Joint rings shall be supplied by the pipe manufacturer.

Each joint ring shall be marked clearly and durably in accordance with the following information in a manner that does not interfere with the sealing function of the ring, in complying with clause **3.9 of BS 2494: 1990**

- a). The nominal size
- b). Manufacturer's identification
- c). The number of the BS or BSEN with seal type designation
- d). Abbreviation for the elastometer

M. Flange Joints for Pipes and Pipeline Fittings

Flanges for pipes and pipeline fittings shall unless otherwise stated comply with BS 4504: section 3.1: 1989 and BSEN 1092: Part 2: 1997. Flanges shall be of PN16 nominal pressure rating and shall be raised faced, unless otherwise stated.

Flanges in accordance with BSEN 545 and ISO 2531 are dimensionally compatible with BS 4504: Section 3.1.

Flanged joints shall be complete with all nuts, bolts, gaskets and two washers per bolt.

The flanges of all fittings shall be integrally cast. The flanges of flanged pipes shall either be integrally cast or screwed and factory welded unless otherwise stated. 'Factory welded' means that the flanges are welded to the pipes at the point of manufacture under factory conditions with inspection agency certification.

The Contractor shall be responsible for checking and ensuring that mating flanges are compatible in all cases, including where connections are required to pipe work and valves associated with pumping plant and inlet/outlet pipe work at service reservoirs or other structures.

1. Steel Flange Converter

Steel Flange Converter shall be made out of polyethylene and shall be conform to the WIS 4-24-01 specification for mechanical fittings and joints including flanges for polyethylene pipes for conveyance of cold portable water for the size range 90-1000 inclusive made of metal or plastics or a combination of both.

2. Gaskets for Flanged Joints

Gaskets for flanged pipe joints shall be of the inside bolt circle type and the dimensions shall comply with BS 4865: Part 1.

The physical properties of gaskets shall comply with Table 3 of BS 2494: 1990.

The Gaskets shall also comply with the relevant provisions in BS 2494 for effects on water quality and resistance to microbiological deterioration.

The Gasket material shall be EPDM/SBR and shall be of average hardness of 76-84.

The Gaskets shall be supplied by the manufacturer and shall suit for PN 16 flanges unless otherwise stated.

Each gasket shall be marked clearly and durably in accordance with the following information in a manner that does not interfere with the sealing function of the gasket, in complying with clause 3.9 of BS 2494: 1990.

- a). The nominal size
- b). Manufacturers identification
- c). The number of the BS or BSEN with seal type designation.
- d). Abbreviation for the elastometre

N. Nuts, Bolts and Washers

The nuts, bolts and washers for flanged joints shall be of high tensile steel and shall comply with BS4395: Part 1 and 2: 1969.

The bolting shall comply with the relevant provisions of BS 4504: Section 3.1:1989.

The Bolt lengths shall be sufficient to ensure that nuts are full threaded when tightened in their final position with two threads showing.

Two washers per each bolt shall be supplied for providing under the head of the bolt and under the nut.

O. Coating

All steel flanges shall be protected against corrosion. The protection shall comprise a coating of metallic zinc or zinc rich. Paint complying with ISO 8179:1985 followed by two coats of bituminous based black paint complying with BS 3416. Type II or an approved coat of epoxy.

Coating shall apply under factory conditions in complying with BSEN 545:1995 or ISO 4179:1985/ISO 6600:1980.

P. Tolerances

Tolerances on wall thickness & weight, and length shall be in accordance with BS ISO 11922 - 1: 1997 or DIN 8074 1999 or ISO 4427

The tolerances on flange thickness and flange diameter shall be in accordance with BS4504: section 3.1:1989.

The tolerances on flange thickness, flange diameter and bolt holes in polyethylene Steel flange converters to be used of connecting different type of material shall conform to BS 4504:1989.

Q. Special Requirements on Transport & Handling

1. Protection during Delivery

The Contractor shall provide methodology of protection of pipes and fittings, to the approval of the Engineer and obtain written approval prior to the pipes and fittings leaving the place of manufacture and shall maintain such protection until the items reach their destination in order to guard effectively against damage during handling transit and storage and ingress of foreign matter inside the pipes & fittings.

All fittings shall be securely packed in crates and boxes to prevent damage during delivery.

2. Storing, Handling and Hauling of Pipes, Fittings and Specials

All materials shall be stored in an approved location and in such a manner as to preserve their quality and condition as recommended by the manufacturer.

Materials and components shall be handled in such a manner as to avoid any damage or contamination and in accordance with all applicable recommendations of the manufacturers recommendations. The Manufacturer shall provide necessary details to the shipping line on precautions to be taken during loading/unloading handling & transport of the pipes, valves and other components, in the sea. The Contractor should follow a set of recommendations of manufacturer for handling, loading, unloading, transporting and storing of polyethylene pipes and fittings.

3. General Principles

The recommendations for handling and storage are the same for both PE 80 and PE 100 pipes although due to their increased stiffness, even greater care may be required in the handling of PE 100 pipe coils than PE 80 pipes of similar wall thickness.

Polyethylene is a tough resilient material which is relatively light and easy to handle although it is prone to damage through scoring by sharp objects. Therefore careful handling is always required and the dragging of straight pipe and coils should be avoided whenever possible.

The maximum allowable depth of scoring of the external surface of the pipe is 10% of the wall thickness. Pipes and fittings showing obvious defects or excessive scoring should be withdrawn, clearly identified as unsuitable and, where appropriate, returned to the source of supply.

The general properties of polyethylene are unaffected by low ambient temperatures but, having very smooth surfaces, the pipes and fittings become slippery in wet or frosty weather. Particular attention should be given to effective securing and storage under such conditions. Extra care should also be taken when handling large diameter prefabricated fittings during very cold weather.

The packaging of pipes by the manufacturer is normally consistent with the requirement to prevent damage and to comply with safety considerations. Usually pipes are delivered strapped into convenient bundles or banded coils. Fittings are normally supplied in separate bags or cartons together with any associated small items, such as bolts and gaskets.

As far as practicable the protective packaging (pallets, strapping, bags etc.) should be kept intact until the material is required for use. The temporary capping or plugging of pipe ends is recommended.

Pipes and fittings likely to be stored outside for periods longer than 12 months should be covered by a tarpaulin or black polyethylene sheeting to prevent ultra violet degradation from sunlight. Electro fusion fittings should be stored under cover and in their protective packaging.

For hygiene purposes, the pipe ends must be protected from the ingress of dirt/water etc. This protection should be carefully disposed of following use.

4. Transport and Delivery

For transporting bulk loads, vehicles should be provided with a clean flat bed, free from nails or other projections, which may cause damage. If high sided lorries are used, special care must be taken to prevent slippage or excessive bowing of the pipes and extra protection given at all sharp edges.

Care should be taken to avoid positioning pipes and fittings near or adjacent to exhaust systems or other heat sources and to avoid possible contamination from materials such as diesel oil. Metal chains or slings should not be brought into direct contact with the material. Webbed slings of polypropylene or nylon are recommended. Straight pipes should be fully supported and bound together. Pipes must not rest on the integral socket, if one is incorporated.

When transporting 'pupped' fittings, these should not be loaded in a way that could distort the pup end.

Both vertical and horizontal deliveries of coiled pipes are permissible, although in the case of horizontal transportation special notification may be required for highway authorities in respect of wide load regulations.

5. Off Loading

a. Bundled Pipes

When lifting by crane, non metallic wide band slings or ropes should be used, and for pipe lengths greater than 6m, load spreading beams of a length at least equivalent to one quarter of the length of the pipe or bundle pack should be employed.

Chains or end hooks should not be used. Care should be taken to avoid damage to pipes and pipe ends during lifting, particularly those pipes with couplers.

Some bending should be allowed for in the middle of the lift when loading and unloading pipes and, because of this, lifting points should always be well spread and evenly spaced.

Standard bundle packs, 6m long, may be handled by fork - lift trucks but due allowance should be made for the flexible nature of the pipes in the positioning of the forks and the raising of the load.

Bundle packs greater than 6m long should be handled either by a side loader with a minimum of four supporting forks, or by a crane using a spreader beam and suitable slings. Individual pipes may be and led in the same way. Off-loading on site may be made easier by using skid timbers and rope slings.

b. Coiled Pipes

Reinforced adhesive tape at least 50 mm wide should be used for banding. Complete coils are secured by outer and intermediate bands and individual layers are also independently secured. These should not be removed until the pipe is required for actual use.

Pipe sized > 63 mm should be moved and uncoiled using an approved dispensing trailer.

Before unstrapping pipe from the coil or drum, both pipe ends must be firmly & mechanically restrained. The band securing the outer end of the pipe should be removed first and the movement of the free end carefully controlled. This removal should be followed with those securing successive layers. No more bands should be removed than necessary to release the length of pipe immediately required. After sufficient pipe has been cut from the coil the protective end cap must be replaced on the remainder. The outer end of the pipe should be suitably re-marked as such.

When removed from the coil or drum, the pipe will be oval and curved. The extent of ovality and curvature will depend upon the temperature, SDR rating, pipe diameter, coil diameter and

material type. Although both ovality and curvature will reduce naturally with time, special hardware is available to facilitate handling and jointing.

c. Fittings

Hooks should not be used to lift fittings which are generally supplied in cardboard boxes or polyethylene bags.

d. Storage at Depot

All materials should be carefully inspected at the time of delivery and any defective material set aside before accepting the delivery into stores. Any such defects should be notified to the supply source immediately.

Materials of different polymer manufacture should be kept separately and clearly identified.

Blue polyethylene pipe should preferably be stored under cover and protected from direct sunlight until required for use. Where storage facilities necessitate the material to be exposed externally, suitable opaque protective sheeting should be used.

All pipe stacks should be made on sufficiently firm, flat ground to support the weight of the pipes and any necessary lifting equipment. Stacking heights should be kept to a minimum and adequate space allocated for lifting machinery to man oeuvre without causing accidental damage.

For safety and the convenience of handling, the stacking height for bundles should not be more than 3 metres. To prevent possible deformation of the pipes, bundles must be stored timber to timber.

For similar reasons, pipe coils should be stored flat and the number of coils per stack should be limited to;

- 7 coils for 20 mm diameter pipe
- 6 coils for 25 mm diameter pipe
- 5 coils for 32 mm diameter pipe
- 4 coils for 50 mm diameter pipe
- 3 coils for 63 mm diameter pipe
- 2 coils for 90 mm diameter pipe
- coils for 110 mm diameter pipe
- coils for 125 mm diameter pipe
- coils for 180 mm diameter pipe

Where individual pipe lengths are stacked in pyramidal fashion, deformation may occur in the lower layers, particularly in warm weather. Such stacks should therefore be no more than 1 metre high. Socketed pipes should be stacked with the sockets at alternate ends and with the sockets protruding to avoid uneven stacking which may permanently distort the pipes.

Polyethylene fittings should be stored under cover, preferably on racking and in the manufacturer's protective wrapping or cartons which should be kept intact until the fitting is required for use.

At all times pipes and fittings should be stored away from exhaust outlets and all other high temperature sources. Care should also be taken to avoid contact with lubricating or hydraulic oils, gasoline, solvents and other aggressive chemicals.

All special tools and equipment associated with the jointing of PE pipes and fittings should be stored separately and securely until they are required for use. The heating faces of fusion tools should be kept in a position where the surfaces are protected from scratching or other damage. Tools incorporating cutting edges should likewise be protected from damage that could cause poor joint preparation.

R. Specification for Butt-fusion Welding Machine

- Machine shall be hydraulically operated and suitable for welding of PE pipes .
 - Machine shall consist of self –aligning frame and compact dimensions, to be suitable for working on narrow roads.
 - Machine shall be comprised of four clamps in lightweight alloy of which the third one is easily adjustable in order to weld special pieces, and the automatic disconnecting devices to detach the pipes the heating mirror at the end of heating time.
 - Heating mirror shall be silver stone coated with electronic thermostat and separate thermometer in order to continuously check the temperature of the heating mirror. Operating electricity requirement of the heating mirror shall be 230V 50Hz. Also it shall include removable electric facing tool complete with reducing gear, double cutting edged blades, safety micro switch all which allow the engine to start only in operating position.
- i. An electrically operated mechanical block device avoiding dislocation during the facing operation. Operating electricity requirement shall be 230V, 50Hz.
 - ii. A support for facing tool and heating mirror suitable to carry the two part and to hold them when it is not in use.
 - iii. Hydraulic double throw pump with precision pressure gauge (class 1.0-100 bar scale and 100mm face to easy reading) incorporates a device which maintains pre-set line pressure even when motor is not running. Allows continuous pressure adjustments and features flexible hoses with quick disconnect dry-lock couplings. Mounted in a tough protective frame, with two transport handles. Operating electricity requirement is 230V 50Hz.
 - iv. Light weight aluminium reducing inserts (8 inserts per set including 6 inserts for pipes and 2 inserts for fittings) sizes 200,225,250,280,315,355,400,450mm.
 - v. Upper fitting clamp d.500mm for short fittings.
 - vi. Stub end device with size range 200 to 500 mm.

2.09 Low Density Polyethylene Pipe for House Service Connections

- A. Outside diameters and pressure class shall be in accordance with ISO 161/1 - 1978 (E) and minimum wall thicknesses (e) are calculated using the ISO formula with a working stress (p) of 32 kgf/ cm²:

$$e = \frac{P.d}{2 + P}$$

- B. Pipe supplied shall be Class 10 and maximum sustained working pressure is based on water at a service temperature of 30o C.

C. Pipes shall conform to the outside diameters and wall thickness given in below:

Nominal Diameter ND	Outside Diameter		Wall Thickness Class 10		Coil Length	Minimum Coil Weight
	Min	Max	Min	Max		
mm	mm	mm	mm	mm	m	Kg/coil
25	25.0	25.3	3.4	3.7	200	43
32	32.0	32.3	4.4	4.8	150	53
50	50.0	50.4	6.8	7.5	150	129
63	63.0	63.3	8.6	9.4	100	137

D. Visual Requirements. Pipes shall be free from gouges, voids and other defects that would, in the judgment of the Engineer, impair the serviceability of the pipe.

E. Material composition shall be in accordance with BS 1972:1967.

F. Mechanical properties shall be in accordance with BS 1972:1967.

G. Sampling and testing shall be in accordance with BS 1972:1967. Copies of factory test reports shall be made available to the Engineer upon request. Witnessing by the Engineer of factory testing shall be required prior to delivery of any consignment.

H. All pipe coils shall be indelibly marked in blue colour at intervals of not more than three metres with the manufacturer's name, specification number and nominal size and class as shown in the table above.

I. Pipes shall be supplied in coils and lengths and minimum weight per coil shall be in accordance with the table above.

J. Each delivery of polyethylene pipe to the site shall be accompanied by a certificate from the manufacturer certifying compliance with these specifications. Any deviations found in random checks by the Engineer on coil lengths, coil weights, pipe dimensions and any failure in hydrostatic pressure tests shall be considered a cause for rejection of the entire consignment.

K. Fittings for low-density polyethylene pipe shall be manufactured from Acetal or Gunmetal and shall have bodies with internal taper, grip ring for end loading resistance, and "O" ring for water tight seal. All components shall be manufactured from UK WFBS listed materials. Seal of the push-fit joint is obtained using water pressure as a thrust medium and hence no tool is used to obtain a watertight joint. Supplier to be approved to BS 5750: Part 1:1987; ISO 9001-1987 for supplier quality management systems. Materials shall conform to the following:

1. gunmetal fittings -BS1400:LG2 cast gunmetal
2. plastic fittings -threaded generally Dupont Derlin 107 black 601, Acetal Homopolymer; all other fittings Hoechst T 1020 black R2 Acetal Terpolymer.
3. components -grip ring; Acetal polymer "O" ring;

- L. EDPM elastomer to BS 2492 type W, such as Millflex M28, Victaulic EP52, Exxon 584/111 EDPM or Wooduolle Polymer 09-333.
- M. Fittings shall be designed for use underground and to handle potable water at temperatures up to 60°C. They shall be capable of test operation at a pressure of 25 bars without leaking. Adapters for connecting polyethylene and G.I. pipe shall be designed with an inlet for metric size PE pipe and a female threaded outlet to BS 21:1975 or ISO 7/1 for galvanized iron pipe to BS 1387.

2.10 Ferrules and Saddles

- A. Ferrules shall be supplied with a push-fit outlet for PE. All ferrules shall be designed as a main stem with a 360° swivel outlet at 90°, with control of water flow via a threaded inner plug. The inlet shall be a male taper threaded to BS21: 1975 or to ISO 7/1. Ferrules shall be designed for use underground and to handle potable water at temperatures of up to 50°C and shall be capable of working at a pressure of 21 bar without leaking. Ferrules shall be easily "shut off" by means of spindle extending from the top cap. Design of the ferrule shall further permit use with conventional drilling machines, which mount on to the ferrule/saddle assembly to drill the main via the ferrule stem waterway, dry or under pressure. Ferrule stem, inner plug and top cap shall be manufactured of Gunmetal/Bronze to BS 1400:1986 LG2. The ferrule banjo may be manufactured of gunmetal/bronze or acetyl. Banjo washer and the top cap washer shall be manufactured in nitrile rubber to BS2494 and shall provide the sealing between the outer body and ferrule stem.
- B. Saddles for installation on asbestos cement pipes shall be of cast gun-metal to BS 1400 LG2 and shall be supplied with aluminum bronze or stainless steel bolts and nuts and synthetic nitrile rubber gaskets. They shall have an untapped boss on the top surface suitable for installation of the approved ferrule. All saddles shall accept ferrules up to 50 mm diameter. All strap bolts shall be fully threaded.

2.11 Galvanized Steel Pipes and Fittings

- A. Galvanized steel pipes and fittings shall conform to BS 1387 or ISO R49. Fittings shall be galvanized malleable cast iron complying with BS 1256.
- B. Where indicated on the Drawings, or otherwise required, "Denso" tape, or equal, shall be used for corrosion protection of buried galvanized pipe and fittings. Tape shall be applied in accordance with the manufacturer's recommendations.

2.12 Stopcocks

- A. Unless otherwise specified or directed, stopcocks shall be gunmetal 12mm BS1010.
- B. Stop valves supplied with female thread inlet and 12mm female thread outlet.
- C. Valves shall be provided with a detachable key operator with the spindle shielded so as to prevent unauthorized operation with a wrench.
- D. Jumpers shall be fixed.

2.13 Consumer Meters

- A. Consumer meters shall be volumetric rotary piston type meters complying with the requirements of BS 5728/1 or ISO 4064/1, Class C suitable for water temperatures up to 50°C, a working pressure of 10 bar and exposed outdoor location. Meters shall indicate water consumption by means of a counter resetting to zero at 10 000 cu m consumption for 15 mm size meters and 100 000 cu m for larger size meters. Meters shall indicate to 0.1 litre consumption for 15 mm size meters and 1 litre for larger size meters. Counters shall have black numerals on white to denote cubic metres and white numbers on red to denote litres. Meters shall be supplied with bodies having B.S. male threads. Meters shall be Kent PSM meters or approved equal. Where directed by the Engineer, meters of 50 mm and above shall be of the helical vane combination type having a PSM by-pass and metric registration.

2.14 Mechanical Couplings

- B. Grooved end couplings shall engage and lock the grooved or shouldered pipe ends allowing some degree of contracting, extension, and angular defections. Coupling housing shall be of ductile iron or malleable iron and consist of two or more segments held securely together by at least two steel bolts. Sealing gaskets shall be of such design that internal pressure in the pipe increases the tightness of the seal and shall be of materials suitable for the intended service. Couplings shall have a rated working pressure not less than the pressure rating of the pipe.
- C. Flexible couplings shall be provided with all necessary nuts, washers and gaskets plus an extra 10 percent to cover wastage. All nuts, bolts and washers shall be of alloy or carbon steel conforming to BS 970 Part 1, Grade 070 M20 or JIS G4051 320C or approved equal. Bolts and nuts shall be supplied with two washers per bolt. Bolt length shall be such that after the joints are made up, the bolts protrude through the nut, but not more than 12 mm. Flexible (sleeve) couplings shall be of the full sleeve long type, split sleeve type or flanged adapter type, as shown on the Drawings, specified herein, or as otherwise permitted by the Engineer.
- D. Full sleeve couplings shall be the long type, properly gasketed and shall be of a diameter to fit the pipe. Each coupling shall consist of a steel middle ring, 2 steel followers, 2 gaskets, and the necessary stainless steel bolts and nuts to compress the gaskets. Stepped Couplings of the general type shall be used when stepping from one pipe material to another of the same nominal diameter.
- E. Split sleeve type couplings shall consist of one gasket, 2 housing clamps, and 2 stainless steel bolts, nuts and washers to obtain the flexibility for connecting the piping. Steel shoulders shall be provided and welded to the pipe ends to accommodate the couplings.
- F. Flexible flanged coupling adapters shall be of the sleeve type, consisting of steel middle ring, steel followers, gaskets, and stainless steel bolts, nuts and washers to compress the gaskets. Couplings shall contain stainless steel anchor studs of strength adequate to hold the pipe together under a pull equal to the longitudinal strength of the pipe at a tensile stress of 140 MPa. They shall provide the requisite pipe flexibility without

jeopardizing pipe joint integrity due to hydraulic thrust and shall have the same pressure-rating as the pipe. All flexible couplings and flanged adapters shall be restrained unless the Engineer has given his approval to omit this feature for specific cases. Couplings shall have all metal bearing surfaces and shall be internally and externally fusion bond epoxy coated as specified paragraph 2.01 E 2b.

2.15 Wall, Floor, Slab, and Roof Penetrations

A. Wall pipes shall comprise:

1. ductile iron wall pipes with integrally cast seep ring with ends. If standard castings with integral seep ring are not available provide special castings that will provide a watertight installation,
2. wall thickness shall be equal to, or greater than, that of adjacent piping, and in compliance with the requirements for fittings,
3. rubber-gasketed compression collars are not acceptable. The welding or brazing of seep rings to ductile iron wall pipes is not acceptable,
4. tap flanges set flush with the face of the wall for stud bolts,
5. coat wall pipes as specified in Section 09870.

B. Pipe Sleeves shall comprise:

1. galvanized steel pipe or 18 gage galvanized steel sleeve with center flange for water stoppage,
2. caulk shall be rubber sealant,
3. mechanical closures shall include:
 - a. interlocking synthetic rubber sealing links shaped to continuously fill the annular space between the pipe and the sleeve,
 - b. stainless steel bolts and nuts and steel pressure plates under each bolt head,
 - c. closures sized according to the manufacturer's instructions for the size of pipe shown on the Drawings,
 - d. closures rated to withstand a hydrostatic head of 12m of water,
 - e. coating to pipe sleeves as specified in Section 09870.

2.16 Marker Posts

- A. Marker posts, as detailed on the drawings, shall be installed at the locations of all valves, air/vacuum valves, washouts and access manholes. The type, depth, location and diameter of
- B. the main shall be indicated on the post. The Contractor shall obtain the approval of the Engineer on the location of marker posts and the permission of the RDA or municipality in the location within road property limits.

2.17 Sewer Manhole Requirements

- A. Manholes shall be constructed in accordance with the details shown on the Drawings. The interior face of manholes and access shafts shall be formed from GRP pipe (minimum STIS) 2500 N/mm² used as permanent lining. The pipe shall withstand all loads imposed during concrete placement (with the standard approved bracing) and any future ground water pressure (without bracing). Suitable GRP formers shall be provided

for cover and reducing slabs. Backdrops to manholes (pipes & fittings) shall be constructed vertically adjacent to the external face of the manhole shaft in order to reach the invert level inside the manhole. The material shall be vitrified clay pipe manufactured to EN 295 standard and as shown on drawings.

Part 3 Execution

3.01 Pipe Installation

A. General

1. the Contractor shall supply all necessary tools for cuttings, chamfering, jointing, testing and for any other requirement for satisfactory installing the pipelines.
2. pipes and fittings including any sheathing, sleeving, lining or protective coating, shall be inspected by the Contractor immediately before and after installation. Any damage shall be repaired by the Contractor, as directed by the Engineer, before the pipe, or fitting, is installed or jointed. Any specified material required for the repair of pipe, sheathing, sleeving, lining or coating shall be obtained by the Contractor and shall be used in accordance with the Manufacturer's recommendations. The Engineer may, and without relieving the Contractor of any of his obligations, inspect and test the pipe and appurtenances by any means he considers appropriate. Any damage discovered by such inspection shall be repaired by the Contractor. The Contractor shall remove from the Site any pipe or appurtenance, which, in the opinion of the Engineer, is so damaged as to be unfit for incorporation in the Works. Replacements for damaged pipes or fittings shall be obtained by the Contractor at his cost.
3. the Contractor shall furnish, install and operate all necessary machinery, appliances, and equipment to keep the excavation sufficiently free from water during construction of the work to permit proper laying and jointing all as described in Section 02220.
4. for the purpose of reducing the angular deflections at pipe joints, and for closure sections, the Contractor shall be permitted to install pipe sections of less than standard length. Closing sections and short sections of pipe shall be fabricated and installed by the Contractor as found necessary in the field. Where closing pieces are required, the Contractor shall make all necessary measurements and shall be responsible for the correctness thereof.

B. Joints

1. requirements of this clause shall be read in conjunction with the particular requirements specified elsewhere for joints of particular kinds. Joints shall be made in accordance with the manufacturer's instruction and as specified herein. Before making any joints the Contractor shall ensure that the interior of each pipe or valve is clean and that it remains clean. Immediately before starting a joint, the Contractor shall clean the end of each pipe to be joined and shall otherwise specially prepare the ends for jointing as may be necessary for the particular kind of joint. All mechanical joints shall be cleaned
 - a. and have their paintwork or coating made good before assembly.
Contractor shall use
 - b. only the proper jointing materials (gaskets, nuts, bolts, washers, lubricants) as

c. specified and obtained through the respective suppliers of pipes, couplings or valves. All joints shall be accurately made and shall be capable of passing tests for individual joints and for the completed pipeline as may be specified. Graphite grease shall be applied to the threads of bolts before mechanical or flanged joints are made. After completing a joint, any protective paint or coating shall be made good, and any metal joint, which is not already coated, shall be cleaned and painted with two coats of polyurethane paint. Additional external protection of joints where ordered by the Engineer shall be carried out as specified.

2. for rubber ring joints, the hardness of the rubber shall be such that the joint, when made on the installed pipes, will be watertight, as specified, under any combination of working or test loads. Immediately before assembling, each joint incorporating a rubber ring seal shall be inspected for cracks. Each part of the ring shall be arched by hand into a radius of approximately 150mm. If, under this deformation, any cracks are either revealed or initiated the ring shall be rejected and shall be cut through completely to prevent inadvertent use, and the matter reported forthwith to the Engineer. If more than three successive rings, inspected in this way, are rejected, the Contractor, shall on the instruction of the Engineer, stop all pipe jointing until the cause of the defect has been proved and remedied to his satisfaction. Rubber rings shall be placed in the groove on the socket or spigot ring, and the spigot end of the pipe then entered into the socket of the adjoining pipe and forced into position. Care shall be taken to avoid twisting or cutting the ring when jointing the pipe. The inside surface of the socket shall be lubricated with a compound, recommended by the manufacturer, and which will facilitate the telescoping of the joint.
3. where mechanical joints are approved, installation shall be in accordance with the manufacturer's recommendations. The Contractor shall render the end of each pipe perfectly smooth so as to allow the joint sleeve to slide freely and, where necessary, shall coat the pipe ends with two coats of an approved quick drying sealing and protective compound. Where specified and/or directed by the Engineer, end movement of pipes jointed by the coupling shall be restrained by a steel work harness, which shall be cleaned and painted with two coats of polyurethane paint or painting system compatible with that of the pipe. Joints shall be moulded with a suitable material as recommended by the manufacturer or directed by the Engineer. Installation of couplings and flanges shall be strictly in accordance with the manufacturer's instructions and the tightening of bolts shall be done progressively drawing up bolts on opposite sides a little at a time. Bolts shall be tightened with a torque wrench to the torque recommended by the manufacturer so as to ensure even pressure all round the joint. The appropriate lubricants, as recommended by the manufacturer, shall be used when installing gaskets, in the absence of which soapy water may be used as directed by the Engineer. As the greatest gasket pressure loss occurs throughout the first 24 hours after pressuring the main, the Contractor shall re-torque the bolts again to that recommended by the manufacturer after 24 hours and ensure that the pipe is supported adequately all round.
4. flanged joints for ductile iron pipe and specials shall be made with gaskets and steel bolts and nuts which shall include two washers per bolt. The use of jointing paste or grease will not be permitted. Gaskets may be fastened to the bolts with

cotton thread. The bores of abutting pipes or fittings shall be concentric and no jointing material is to be left protruding into the bore. All nuts shall first be tightened by hand and nuts on opposite sides of the joint circumference shall then first be alternately and progressively tightened with a torque wrench to the torque recommended by the manufacturer so as to ensure even pressure all around the joint. Joint shall be moulded with suitable material as recommended by the manufacturer or directed by the Engineer.

5. GRP pipe joints shall be assembled strictly in accordance with the manufacturer's instructions for the type of flexible joint provided and cutting of pipes will not be permitted.
6. screwed joints on galvanized steel piping and elsewhere shall be made using PTFE tape.
7. for the purpose of reducing the angular deflections at pipe joints of polyethylene pipes, and for closure sections, the Contractor shall be permitted to install pipe sections of less than standard length. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. Butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements of 205°C, alignment, and 517 kN/m² interfacial fusion pressure. Butt fusion joining shall be 100 percent efficient offering a joint weld strength equal to or greater than the tensile strength of the pipe. Socket fusion shall not be used for pressure pipe applications nor in fabrications where shear or structural strength is important. Flanges, unions, grooved-couplers, transition fittings and some mechanical couplers may be used to mechanically connect HDPE pipe without butt fusion, in accordance with the manufacturer's recommendations.
8. anchorage lugs shall be provided for socket and spigot fittings, and socket clamps and tie rods used, where there is a possibility of pulling the joint under pressure. Where specified, restrained joints or concrete thrust blocks will be used in lieu of the above where socket and spigot pipe is used below ground.
9. unless otherwise specified, metallic mechanical joints, flanged joints and ferrule and saddle straps shall be protected by the cold application of Densyl tape or equivalent. Application of Densyl tape with Denso Primer, Densyl Mastic and Outerwraps or equivalent shall be strictly in accordance with the manufacturer's recommendations.

C. Pipe Installation

1. The Contractor shall, after excavating the trench and preparing the proper bedding for the pipe in accordance with Section 02221, furnish all necessary facilities for properly lowering and placing sections of the pipe in the trench, without damage and properly install the pipe. The section of pipe shall be fitted together correctly and laid true to line and grade in accordance with the benchmarks established by the Contractor. The full length of the barrel of the pipe shall have a uniform bearing upon the bedding material and if the pipe has a projecting socket, suitable excavation shall be made to receive the socket, which shall not bear on the subgrade.
2. No pipe shall be rolled into place for lowering into the trench except over suitable timber planking, high enough for the socket to clear the ground and free from roughness likely to damage any coatings. Before laying, each pipe shall be cleaned out and inspected for defects. Any defective, damaged or unsound pipe

shall be rejected. Piping shall be placed when trench and weather conditions are suitable and no pipe shall be laid in water or mud.

3. Any damage to the protective coating of the pipe or fittings shall be carefully repaired before installation. All sheathed pipes shall be checked for continuity of the applied protection by a "Holiday" detection unit. Discontinuities and pinholes indicated by the test shall be made good. Pipes shall be inspected for damage to any internal lining. All damages shall be repaired before installation.
4. Pipes shall be laid with any class identification marks uppermost. Pipe sections shall be so laid and fitted together that the pipeline will have a smooth and uniform interior. The pipeline shall be clean and unobstructed at the time of its completion and acceptance and shall be true to the line and grade as shown on the plans and profile. Spigot and socket pipes shall be laid upgrade without break from structure to structure and with the socket end upgrade. Whenever work ceases on any pipeline, the unfinished end of the pipeline shall be securely closed with tight fitting plug or cover.
5. Before any pipe is lowered into place, the bedding shall be prepared so that each length of pipe shall have a firm and uniform bearing over the entire length of the barrel. Pipes shall be laid in straight lines, both in the horizontal and vertical planes, between structures or, where directed in the case of pressure pipes and larger diameter pipelines, to regular curves. Each pipe shall be plumbed to its correct line and directed and accurately sighted by means of a laser positioning system. Alternative methods of locating and leveling pipelines may be allowed subject to the approval of the Engineer. Each pipe shall be carefully lowered onto its prepared bed by means of necessary slings and tackle. A recess shall be left in the prepared bed to permit the sling to be withdrawn. If the prepared bed is damaged the pipe shall be raised and the bed made good before pipe laying is continued. Any pipe which is not in true alignment, both vertically and horizontally, or shows any undue settlement after laying, shall be taken up and relaid correctly by the Contractor at his own expense. All adjustments in line and grade shall be made by scraping away or filling and tamping in under the barrel of the pipe and not by wedging or blocking. Sub-soil water shall be kept below the joint when jointing. In no case shall pipes be jointed before being lowered into position. If any damage should occur to any pipes through failure of the Contractor to comply with these conditions, the damage shall be made good at the Contractor's expense. All pipelines adjoining structures shall have a flexible joint near the face of structure as detailed.
6. The formation level of the excavated trench surface shall be firm and true to grade and compacted to a minimum of 95 percent maximum dry density before placing of pipe bedding. If soft, spongy, unstable, or similar, other material is encountered upon which the bedding material or pipe is to be placed, and the specified compaction cannot be achieved, this unsuitable material shall be removed to a depth ordered by the Engineer and replaced with compacted bedding material, or as instructed by the Engineer. Pipe bedding and concrete barriers shall be in accordance with Section 02221.
7. Concrete protection of pipe shall be in accordance with Section 02221.
8. Where a change of direction to deflect pipelines from a straight line, either in the vertical or horizontal planes, to avoid obstruction, or where long radius curves are permitted or specified, the amount of deflection allowed shall not exceed that required for satisfactory connection of the joint, and shall be approved by the

Engineer. The maximum deflection shall not exceed 75 percent of that recommended by the manufacturer unless otherwise approved by the Engineer. Where a change of direction cannot be made by deflection at the joints of ordinary straight pipes, bends shall be used. The locations of such bends and other special are indicated on the Drawings and their exact positions will be determined by the Engineer on site. All pressure pipelines shall be secured at all changes in direction by concrete anchor blocks or by restrained joints.

9. All flexible pipelines except 100 mm diameter, or smaller, pipes will be subjected to deflection measurements at site by passing a suitable ball through the pipeline. The ball should be sized so that its external diameter equals the calculated installation deformation plus the recommended two percent allowable tolerance for isolated extremes. Any sections of pipe failing to meet the specified deflection criteria shall be removed from the trench and relaid if the pipe is not damaged. This procedure shall be repeated until the pipeline is found to be satisfactory. Removal from the trench and relaying shall be at the Contractor's expense. If the permanent set or deflection, after removal, exceeds the limits set out below, the pipes shall be deemed to be damaged and will therefore be condemned. The pipes so condemned shall be indelibly marked, removed from the site and replaced at the Contractor's expense.
10. The maximum deflections for flexible pipes with granular bedding (measured-in-situ) shall be:
 - a. after completion of surround: 0 percent
 - b. one month after reinstatement of trench: 2 percent
 - c. immediately prior to issue of Final Certificate: 4 percent
 - d. immediately prior to commissioning: 4 percent
 - e. deflection of pipes installed with concrete surround shall be measured when the concrete has set and the deflection shall not exceed 2 percent.
 - f. Any pipe exhibiting a greater deflection shall be broken out. Deflections shall be considered as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis divided by the non-deflected diameter and shall be measured by an approved mechanical device at any points determined by the Engineer.
11. Back-filling should be carried out in accordance with Section 02221 and where concrete surround is provided shall not be placed before the compressive strength of the concrete has reached 15 N/mm².
12. The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines. The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing. No extra payment will be made for such adjustments nor for any welding, couplings, fittings, or special lengths required to meet this requirement. A reasonable tolerance in the location of lines, fittings, and appurtenances will be permitted by the Engineer to enable the minimum use of special lengths. Cutting of reinforced concrete and GRP pipes will not be allowed. Special lengths of pipes shall be manufactured for closure as required. The cutting of vitrified clay pipes, uPVC, DI and asbestos cement pipes for inserting specials, fittings or closure pieces shall be carried out in a neat and workmanlike manner and without damage to the pipe and so as to leave a

smooth end at right angles to the axis of the pipe by an approved cutting machine as under:

- (a) cutting ring for 100 to 150 mm
- (b) cutting chain for 100 to 450 mm
- (c) disc cutter for all diameters

Only experienced men shall be employed by the Contractor on this work. The Contractor shall take every precaution to ensure that both the measurements and the cutting of pipes are to the accuracy required. Should any errors occur, the Contractor shall remedy them at his own expense and as the Engineer directs.

13. Work at any crossing of a watercourse shall be carried out as expeditiously as possible to the satisfaction of the Engineer and any responsible Authority with the minimum interference to the free flow of water in the watercourse. Details of any temporary works which may affect the watercourse shall be submitted to the Engineer at least 14 days before starting work. Where the pipeline passes underneath a river, stream or ditch, unless otherwise detailed on the Drawings it shall be encased in concrete and the minimum thickness shall be 150 mm. Unless otherwise shown, the depth of cover shall be not less than 600 mm from the bed of the river, stream or ditch to the top of the concrete. The Contractor shall fill the trench in both banks with rock fill or concrete up to levels as shown on the Drawings or as directed by the Engineer. The extent of this work may be varied to suit each individual crossing. Unless otherwise ordered, the concrete encasement of the pipe shall extend at least to a section vertically below the tops of the banks. Protection against erosion to the banks shall be provided by means of stone pitching or riprap or gabions where shown on the Drawings.
14. Pipe hangers and supports shall be of standard manufacture and provided in compliance with the following general requirements. Piping shall be supported independently from equipment or structures to which it is affixed. All weight of piping and contained fluids shall be transferred to a structural or foundation system through the individual or combined use of bedding, pipe saddle supports, or overhead hanger systems. A support shall be provided for each pipe at or near the point where it is connected to machinery, valves or structures. A support shall be provided for each valve and special fitting.
15. All pipes built into a concrete wall or structure shall be provided with two flexible joints adjacent to the structure as shown on the drawings. Flexible pipes constructed into a concrete wall or structure shall be protected with a concrete surround integral with the external face of the structure as shown on the Drawings. All internal and external protection membranes to the concrete shall be sealed around the pipe openings as recommended by the membrane manufacturer. Any over-excavation adjacent to a structure and/or beneath the formation level of a pipeline, either to be constructed under the contract or in a future contract, shall be backfilled with Grade 20 concrete. Alternatively, the Contractor may propose a different method for supporting the pipeline for the approval of the Engineer. Approval to the use of compacted backfill alone will not normally be given.
16. The pipeline, chamber, vaults and manholes shall at all times be kept free of all silt, mortar, debris and other obstructions. When work is not in progress, the open ends of the pipeline shall be securely plugged with an approved watertight plug or stopper firmly fixed to resist unauthorized removal. Claw type plugs or

any type liable to damage the pipe will not be approved. All such stoppers, plugs or caps shall be provided with a vent incorporating a valve for the purpose of testing whether the pipeline is under pressure or vacuum and to enable pressures to be equalized prior to its removal. The Contractor shall clear the inside of each fitting and pipe length immediately prior to jointing and shall swab all fittings and pipe lengths to remove all dirt, sand or other matter that may clog the line or contaminate the fluid to be transported in the pipeline. After jointing, the interior of the pipes shall be freed from any dirt, stones or other matter that may have entered them. For this purpose, a rubber disc, brush or other suitable implement that will not harm the internal lining of the pipe shall be pulled through the pipe after jointing. The Contractor shall enter the pipeline at access manholes to remove large sediment deposits or other items.

17. Installation of Exposed Galvanised Steel Piping

All galvanized steel piping shall be fixed to walls and ceiling with galvanized malleable iron brackets conforming with BS 1494 Tables 6(a) and 7(a), with screwed backplates or tails. Where required extended brackets shall be used which shall consist of galvanized malleable iron pipe rings as Table 13(a) with screwed galvanized mild steel rods split for building in or with screwed backplates as Table 10(a). Brackets shall be fixed in accordance with the following table on straight runs and, in addition, at all bends and fittings.

	Centres (m)	
Diameter of tube (mm)	Vertical	Horizontal
12	1.80	1.20
15 & 25	2.40	1.80
32	3.00	2.40
38 & 50	3.60	3.00
65 & 75	4.50	3.60
100	4.50	3.90

3.02 Pipeline Identification

- A. All exposed and/or non-buried pipe, including tubing, galvanized pipe, polyvinyl chloride pipe, GRP and stainless steel pipe, shall be identified by color to show its use function. Identification of piping systems shall conform to the requirements of Section 09870. Colour bands of an approved tape type may be used on PVC, and all other pipe not readily susceptible to painted finish. Markers shall be adhesive type with extra strength and suitable for continuous duty at 120°C. All markers shall have a protective silicone film. The colors shall be in accordance with Section 09870. Both the direction of fluid flow, and the name of the fluid in the pipe shall be stenciled on all pipe at least once every six metres and at every change of direction. Color bands shall be spaced at four metre intervals and every change in direction. The size of the letters and color bands shall be as specified in the table below:

Outside diameter of pipe or covering (mm)	Width of color band (mm)	Height of legend or letters (mm)
10 to 30	25	5

40 to 50	25	15
60 to 150	150	50
200 to 250	150	60
Over 250	150	90

3.03 Pipeline Structures and Appurtenances

A Manholes. A concrete manhole shall be constructed at each change of gradient or direction, at each intersection with other sewers, at such other points as shown on the Drawings and as directed by the Engineer. Channel inverts shall be accurately laid to meet pipe invert elevations at the same time as the sewer pipes are laid. Channel bends in the benching are to be as "slow" as possible by setting the manholes "off-center" at changes in direction. Short lengths of pipe with flexible joints shall be provided at entry and exit to manholes. Manhole bases shall be constructed with concrete formed to the required shapes with GRP formers. Manholes shall have protective linings and coatings as described in the Specification. Manhole covers generally shall be set to the paved area profile and be flush with the paved area surface. Manhole covers located in unimproved areas shall be set at an elevation to prevent the entry of surface water as directed by the Engineer. Where drop manholes are indicated, they shall be as shown on the Drawings and shall be formed where the upstream length of sewer enters a manhole at a higher level than the manhole invert level. All manholes shall be watertight on completion. Where leakage is discovered the Contractor shall perform such work and provide all materials as are necessary to render such faulty work watertight. The Contractor is warned that he should expect rubbish and debris to be deposited in manholes, chambers or vaults during the course of construction and should take necessary measures to ensure that such are not used as rubbish and waste dumps.

B Chambers for valves, air valves, washouts, etc. shall be constructed with the details shown on the Drawings, or as directed by the Engineer. Each air valve shall be fixed with isolating valve, whether or not indicated on the Drawings.

C At the locations shown on the Drawing or directed by the Engineer at site, the Contractor shall connect new pipelines to the existing pipelines or structures but not until the new works have passed final tests. Existing mains and service pipes shall only be cut using special equipment approved by the Engineer. The cut shall be perpendicular to the center line of the pipe and special care shall be taken with respect to the location of the cut to ensure that the new pipework shown on the Drawings may be installed. The Contractor shall agree with the Engineer the length of existing pipework to be removed. The Contractor shall take every care to avoid any dirt or extraneous material entering the existing main or service pipe. The Contractor shall have available at the site of the connection efficient dewatering pumps before commencing any cut into existing mains or service pipe in order that the excavation remains dry at all times. Work shall be carried out in a clean and efficient manner. The Employer may put the interconnection into use as soon as possible after its installation and will carry out an inspection to detect any evidence of leakage. Any remedial work, necessary to eliminate leakage, shall be carried out by the Contractor. No pipework shall be covered or backfilled until the Engineer is totally satisfied that the interconnection is free of all leakage.

D The Contractor shall construct all anchors and thrust blocks as required and where specified in the Particular Specifications. Generally, thrust blocks will be placed at all changes

in pipe direction greater than seven degrees. Thrust blocks shall be constructed to the dimensions shown. Unless otherwise specified or directed anchor/thrust blocks shall be provided on pipelines laid to gradients steeper than 1:20 as follows:

- a. up to 1:15 every third pipe,
- b. up to 1:10 every second pipe,
- c. at 1:5 every pipe shall be anchored.

E Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both faces of anchor blocks. Each thrust block shall be designed to have a sufficient bearing area and shall be placed to safely transmit to the surrounding point. Thrust devices shall be cast-in-place concrete, placed between fitting and trench wall or trench bottom, as the case may be. Bearing faces of the block shall be placed against freshly cut and undisturbed trench wall or bottom of sound material. If the thrust exceeds the bearing value of the surrounding soil, the soil shall be pre-compacted before placing concrete. All concrete shall be kept behind the sockets and flanges of fittings. Formwork may be constructed with the approval of the Engineer wherever necessary to confine the concrete to the prescribed dimensions for the block. All form lumber shall be removed before testing. Blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fittings joints will be accessible for repair. Thrust blocks for GRP fittings shall completely encase the fittings, except for the joint area. For fittings larger than 300 mm diameter, a 10 mm thick, 150 mm wide rubber wrap shall be provided on the ends of the GRP fitting such that the rubber protrudes slightly from the encasing.

3.04 Testing

A The Contractor shall submit, for the Engineer's approval, details of his proposed methods and program for testing (including details of test equipment) and shall arrange for all tests to be witnessed by the Engineer, or other person appointed by the Engineer. The Contractor shall provide all things necessary for carrying out testing and cleaning including water, pumps, compressors, gauges, piped connections, stop ends, and all other temporary works. Pipelines shall be properly completed and supported before being put under test except as hereinafter detailed. No testing will be permitted until ten days after thrust blocks and other holding down works have been completed. Trenches shall not be left open at joints prior to testing pipelines except in exceptional circumstances and as permitted by the Engineer who may lay down certain restricting conditions. In addition to any tests of individual joints or other interim tests, which may be specified elsewhere, the Contractor shall submit all parts of the pipelines to a final test. Notwithstanding the foregoing, the Contractor may at any stage of construction, carry out such other tests as he considers desirable to check materials and workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve successful tests under the Contract. All water required for testing and cleaning the pipelines shall be treated or raw water, depending on the final product to be carried by the pipeline, and shall be provided by the Contractor at his cost. Potable water shall be used for potable water lines. All flexible pipelines shall be tested for deflection as described in paragraph 3.01C of this Section. The Contractor should note that neither the satisfactory testing of pipeline, section of a pipeline or any other pipework, nor the acceptance of such testing by the Engineer or his representative shall in any way relieve the Contractor of any of his responsibilities and obligations under the Contract. The Contractor shall notify the Engineer at least 24 hours before hand of his intention to test a section of pipeline having been satisfied, in

the first instance, that the section of pipeline to be tested in the presence of the Engineer is satisfactory in all aspects.

B All pipelines shall be tested by water and shall be physically inspected internally by the Contractor in presence of the Engineer. Pipelines 600 mm to 800 mm may be tested by either air or water as directed by the Engineer.

C All gravity flow pipelines shall be tested by the following tests, to be selected by the Engineer. The Contractor shall, at his own expense, furnish all equipment and materials for making the test. Test (a) shall be performed before backfilling is commenced. Tests (1) or (2) and (3) shall be performed after backfill and compaction is complete, dewatering system removed and after all utilities are in the ground including sewer laterals, but prior to placing of permanent resurfacing. Tests shall be performed in the presence of the Engineer, and shall include the main and laterals as a unit. All pipes are to be clean and empty at the time of testing. When leakage or infiltration exceeds the amount allowed by the specifications, the Contractor shall, at his own expense, overhaul the pipe and make the necessary repairs or replacements in accordance with the specifications to reduce the leakage or infiltration to the specified limits. Any individual detectable leaks shall be repaired, regardless of the results of the test. Leakage tests shall be made on completion of gravity sewer lines as described hereinafter.

1. leakage due to internal pressure (air pressure method). The Contractor shall plug all pipe outlets with suitable plugs, and brace each plug securely where needed. The air test equipment is to be approved by the Engineer prior to testing. Air shall be pumped in slowly to the pipe until a pressure of 100 mm water gauge is indicated on a manometer connected to the system. After the internal pressure of 100 mm water gauge is obtained, two minutes shall be allowed for the air temperature to stabilize within the pipe. Air may be added to restore the pressure to 100 mm water gauge. During a further period of five minutes, the pressure should not fall below 75 mm water gauge without further pumping.
2. leakage due to internal pressure (water-test). All the joints of the pipeline shall be able to withstand a pressure of a minimum 5m head of water, above the crown of pipe at the highest point of pipeline without leakage. Testing shall be carried out before backfilling of the trench. A layer of embedding soil equal to the diameter of pipe shall be laid over the pipe to prevent the lifting of pipe while applying test pressure. However all the joints shall be left open for the purpose of inspection for leakage if any. All branches and open ends shall be closed with stoppers, secured with longitudinal braces/thrust block, before testing commences. Water shall be filled from the lowest point and air allowed to escape through an air vent fixed for the purpose at the highest point of the pipe line section under test. The diameter of air vent shall be about one and half times the diameter of water inlet pipe to allow easy escape of air. No entrapped air shall remain in the pipeline while testing. A pressure of 5 m head of water shall be maintained for one hour to allow initial absorption of water. After that test pressure shall be maintained for 15 minutes and water added shall be measured. If water consumption in 15 minutes does not exceed 0.1 litres/m² of wetted inner pipe surface and if there are no visible leakage through joints the pipeline shall be treated as passed.
3. leakage due to infiltration. The upper ends of the sewer and laterals shall be closed sufficiently to prevent the entrance of water and the pumping of groundwater shall be discontinued for at least three days prior to the test for infiltration. The infiltration shall

not exceed one litre per mm diameter per kilometre per day of that portion of sewer being tested, and includes the length of house laterals entering this section. The total length tested in one section shall not exceed 1000 m in length. This length is dependent upon the type of deflection measuring equipment proposed by the Contractor if flexible pipes are used.

D Pressure pipelines carrying liquids shall be pressure tested as specified herein.

1. Gauges used for testing pressure pipelines shall be either of conventional circular type, not less than 300 mm diameter, calibrated in metres head of water or shall have a digital indicator capable of reading increments of 0.1 metre head. Before any gauge is used, the Contractor shall arrange for it to be checked independently and a dated certificate of its accuracy shall be provided to the Engineer. One additional gauge as above shall be handed over to the Engineer's representative for purposes of verification during testing. Calibration of pressure gauges shall be carried out by the Contractor, at regular intervals, as required by the Engineer.
2. The Contractor should note that since valves cannot be guaranteed to be perfectly drop-tight, testing against closed valves shall not be permitted unless with the written approval of the Engineer. The "open" ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges, or cap ends, additionally secured where necessary by temporary struts and wedges. No claims whatsoever will be entertained on account of leaking valves, or any other difficulties in closing of lengths of pipework for testing, which shall be entirely at the Contractor's expense.
3. The Contractor shall remain responsible for the care of the works during testing of the pipework. For purpose of interim testing, the pipeline shall be divided into sections. Each section shall be separately tested to the Engineer's satisfaction for deflection and pressure when each section is completed. The Contractor shall submit to the Engineer detailed procedures for performing hydrostatic pressure tests of installed piping, fittings, valves, meters and appurtenances for approval. Procedures for performing hydrostatic pressure tests for each section of pipeline shall indicate:
 - location and capacity of the test pump,
 - test pressure at the pump and at the high and low points in the pipeline,
 - procedures for venting the air from the pipeline,
 - disposing the water after satisfactory testing.
4. The length of the section of pipeline to be tested shall not normally exceed 1000 m or as directed by the Engineer. A simple stop end consists of a section of steel pipe about 0.5-1.0 m long onto which a closing plate has been welded, containing the necessary opening for accommodating ongoing water and out-coming air. Stop ends may also include an opening through which the test water may be pumped from the line, if necessary, and shall be jointed to the pipe to be tested by means of a standard coupling or other method approved by the Engineer. Thrust blocks or temporary anchorages shall be provided to hold the stop end in place against the test pressure. The Contractor may also use proprietary restrained joints in lieu of thrust blocks. Interim test shall be carried out after the pipeline section to be tested has been laid, jointed and backfilled to a depth of at least 300 mm above the crown of the pipe but leaving the joints exposed.

Sections to be tested shall be approved by the Engineer. Joints between each tested section shall then be left exposed until the pipeline has passed the Final Test on Completion.

5. Each pipeline or section thereof shall be filled with water and all air removed as far as possible. If permanent air vents are not located at all high points, the Contractor shall install suitable cocks at such points so that the air can be expelled as the line is filled with water. The line shall be filled slowly to prevent possible water hammer. The test pump and gauge shall be connected to the pipeline at a location other than the highest point in the line to facilitate the release of air from the highest point. Pressure in the pipeline shall then be raised steadily up to, and maintained at, the working pressure for a period of not less than 24 hours, to allow for absorption and achieve conditions as stable as possible for testing. The standing period will commence from the time at which the working pressure was reached successfully, after which all exposed joints shall be carefully inspected for evidence of leakage. If neither appreciable movement of the pipeline, nor any leakage, has been observed during the visual inspection, the section shall be subjected to the pressure test proper. Pumping shall then be resumed and the pressure slowly raised to the specified test pressure, at the highest point of the section of pipeline under test, subject to that at the lowest point of the section of pipeline under test shall not exceeding the works test pressure, or as directed by the Engineer. Test pressure shall be continuously maintained by the use of the pump for a period of at least four hours and the amount of make up water required to maintain the pressure shall be accurately measured (to the nearest 1/8 litre) regularly every 30minutes throughout the test. Pipelines with flexible joints shall be deemed to have passed the test if: no water is visible coming out of the pipe or joints at any point; the amount of make-up water required does not exceed the rate of 0.1 litre per millimetre of pipe diameter per kilometre of pipeline per 24 hours for each 30 m head of pressure applied; and the maximum drop in pressure (during the last half hour of the test period, when no further make-up water may be pumped in) shall not exceed 10 percent of the maximum test pressure.
6. For PVC, steel, cast iron, ductile iron or other pipe material, with solvent welded, welded, threaded or flanged joints, no leakage shall be permitted.
7. During all testing, the trench shall be kept clear of water. Should the trench become unstable due to work or leaking on testing or re-testing it shall be excavated to solid ground and made up with lean mix concrete or such other material as the Engineer may direct, all at the Contractor's expense.
8. Should a test fail, the Contractor shall at his own expense replace defective pipes or fittings or make good leaking joints or otherwise rectify defective work. Cleaning, inspection and testing shall then be repeated until the work is to the Engineer's satisfaction and at no extra cost to the Employer.
9. Final acceptance test shall be carried out after all lengths have been joined together on completion of construction and interim tests have been carried out satisfactorily on the entire length of the pipeline, or such other length as may be determined by the Engineer. Final pipeline acceptance test pressures and procedures shall be as described in under pipeline testing.

E All pipelines carrying air or other gasses under pressure shall be given a pressure test as specified herein. No leakage is permitted. Low pressure air piping shall be tested pneumatically. Air pressure of 140 kPa shall be applied to piping and fittings. High pressure air piping shall be tested to 1400 kPa. There shall be no drop in pressure in a 24-hour period. Leaks shall be located and repaired to the satisfaction of the Engineer. Pressure drops due to

thermal contraction are acceptable if the pressure returns to the original test pressure after 24 hours.

F Valves and all pipeline appurtenances shall be hydraulically tested together with the pipeline in which they are installed. Valves shall be tested for operation under working pressure and shall be adjusted so that they operate smoothly, seat properly and are installed to tolerances recommended by the manufacturer.

G All chambers and manholes shall be constructed so as to prevent leakage of water therefrom. Testing for leakage of water from manholes, chambers or vaults shall be conducted, unless it is deemed unnecessary in the opinion of the Engineer. The chambers and manholes shall be hydrostatically tested prior to backfill around manholes and damages revealed as a result of such tests, shall be made good to the satisfaction of the Engineer.

3.05 Disinfection of Pipelines

- A. All potable water pipes, fittings, valves, meters and appurtenances shall be disinfected by the Contractor, as specified herein, unless otherwise directed by the Engineer. All water and chlorine required for disinfection of pipelines shall be provided by the Contractor at his own expense. Bacteriological testing will be performed by an approved laboratory. The attention of the Contractor is directed to the requirements of these specifications whereby he is responsible for preventing the entry of foreign material of any kind into the pipework. The Contractor shall take extreme care to keep the interior of the pipework free of direct and other foreign material. If in the opinion of the Engineer, dirt or other foreign material, which will not be removed by flushing, enters the pipework then the Contractor shall clean and swab the interior of the pipework with a five percent sodium hypochlorite disinfecting solution to the satisfaction of the Engineer.
- B. After testing, and immediately before commissioning, all pipelines shall be washed out and disinfected as follows:
 - 1. All mains shall be flushed out with clean water until there is no evidence of foreign matter or color in the waste flushing water
 - 2. A stock disinfecting solution shall be prepared by mixing, for about 5 minutes, in a clean container, sodium hypochlorite solution (15 percent available chlorine) and distilled water in the proportion of 0.8 litres to 1000 litres water by volume. Stock solutions shall be made up fresh daily;
 - 3. The main, to be disinfected, shall be filled with potable water at the same time as the stock solution is added through a convenient air valve in such quantities (to be determined by the Contractor and approved by the Engineer) as will result in a final solution containing 50 mg/l free chlorine. Care shall be taken to ensure that the stock solution is added at a constant rate, commencing when water is fed into the main and ending as soon as the main is full;
 - 4. Every main charged with disinfecting solution shall stand for 24 hours, after which a sample shall be taken at a washout valve by the Contractor in the presence of the Engineer, from whom the sampling bottle shall be obtained. If the sample does not show at least 2 mg/l free chlorine, disinfection shall be repeated. If the sample is satisfactory the main shall be emptied, flushed out and filled with treated water and allowed to stand for 1 hour;
 - 5. Two further samples shall then be taken as before, one for a further determination of free chlorine and the other, in a sterilized bottle, for bacteriological analysis. If the free chlorine determination shows more than 4

mg/l free chlorine the main shall be flushed out again. If the bacteriological analysis is unsatisfactory disinfection and sampling shall be repeated until satisfactory results are obtained before the main is commissioned;

6. The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines;
7. Water used for disinfection may be re-used in an adjacent section if the level of free chlorine is again brought to the level specified.

3.06 Cleaning of Pipework

- A. It is the responsibility of the Contractor to prevent all dirt and foreign matter from entering the pipework and for cleaning each length of pipe and all fittings, valves, meters and appurtenances, of sand, dirt and foreign matter during the installation.
- B. The interior of all liquid carrying pipework shall be cleaned by the Contractor using clean, potable water after, before and after all pressure tests and disinfection operations have been performed and accepted by the Engineer. Cleaning of chlorinated lines shall conform to the recommendations of the Chlorine Institute. All water required for flushing and disinfection of pipelines shall be provided by the Contractor at his own expense.
- C. Air and gas piping shall be purged with air or inert gas as directed by the Engineer.

3.07 Disposal of Water Used for Testing, Disinfection and Cleaning

- A. Contractor shall provide suitable means for disposal of water used for testing, disinfection and flushing such that no damage results to facilities; structures or property. These means shall be subject to the approval of the Engineer and local Authorities. Details shall be submitted to the Engineer upon request. The Contractor shall be responsible for any damage caused by his filling, testing, disinfecting, flushing and disposal operations.

End of Section 02700

Section 03100: Formwork

Part 1 General

1.01 Description

Provide formwork for cast-in-place concrete as specified herein.

1.02 Quality Assurance

- A. Formwork design, fabrication and erection shall comply with BS 5328 and BS 5975
- B. Erection of formwork shall be executed and supervised by fully qualified personnel with a minimum of five years experience. Formwork systems shall be designed by a registered structural engineer.
- C. Formwork Design Criteria:
 - 1. The erected forms shall be watertight from the ingress of external liquids and egress of internal liquids
 - 2. The design of formwork shall take into account; height and rate of pour; thickness of member; concrete slump and density; placing temperature; texture of finish; construction joints; wind load.
 - 3. On soffit forms (in addition to concrete weight) an additional live load of 2.5 kN/m², or an additional live load of 3.75 kN/m² if a motorised cart is used.
 - 4. The minimum design load for combined dead and live load shall be 6.50 kN/m², or, if a motorised cart is used, 7.75 kN/m².
 - 5. In the assessment of loads, the worst combination of self-weight, formwork forces, reinforcement weight, wet concrete weight, construction loads, wind loads, incidental dynamic effects caused by placing, vibrating and compacting concrete, the use of externally applied vibrators, method of concrete discharge and access for concrete placement and vibration shall be used.
 - 6. Formwork shall be designed to be demountable without shock, disturbance or damage to concrete, and sufficiently rigid to maintain the correct position, shape and profile so that the final concrete structure is within the dimensional tolerances specified in Section 01050 and BS 5328.
 - 7. Soffit formwork, properly supported on shores only, shall be capable of being retained in position during concrete maturing period.
 - 8. Adjustable steel supports and shores shall allow form-boards and framework to be accurately adjusted to line and level.
 - 9. The design shall allow free movement and accessibility under formwork.
 - 10. Shores for abnormal ceiling heights shall be specially designed.
 - 11. Forms shall incorporate 20 mm chamfers on exposed corners of columns, walls and beams, except where plaster or rendered finish is specified
 - 12. The Contractor shall ensure that adequate ground support for shoring and supports is available, and if not, shall take measures to make them suitable.

1.03 Submittals

- A. Shop Drawings
 - 1. Shop drawings shall be in accordance with Section 01300.
 - 2. Shop drawings shall include plans and sections, giving the following minimum information for each level: details of individual panels, position, size and spacing

of adjustable steel shores, position, size and spacing of joists, soldiers, ties, details of formwork for columns, beams, parapets, slab and kickers; details of construction joints and movement joints; details of retaining walls and deep beams showing the position and size of ties, joints, soldiers and sheeting, together with detailed information on erection and casting sequences and construction joints; general assembly details; full calculation sheets; details of all penetrations through concrete; proposed sequence of shoring/re-shoring beams and slabs for different spans and floor heights and number of floors shored, and the stripping time for supported and suspended structural elements, clearly identifying the supported element and suspended element.

3. The Contractor shall allow twenty one days for the Engineer's review.

B. Samples

1. The Contractor shall provide samples of all formwork materials proposed.
2. The Contractor shall provide samples of ties proposed for general situations and for fair faced concrete.
3. The Contractor shall allow twenty one days for Engineer's review of samples.

1.04 Job Example

Prior to commencement of related formwork operations the Contractor shall erect a job example, to a reasonable size including all items such as sheeting, stiffeners, soldiers, ties etc. (and including release agents, where used) for columns, slabs and beams and staircases, and obtain approval before proceeding. For fair face concrete the Contractor shall demonstrate the method used to conceal tie holes. Upon prior consultation, agreement of location and approval, the job mock-ups may remain as part of the finished work.

1.05 Methods

Prior to commencing work, submit to the Engineer details of methods and techniques proposed for the design and completion of formwork.

Part 2 Products

2.01 Form Materials

- A. Form materials shall conform to requirements of BS 5328 and BS 5975 unless stated otherwise.
- B. Unformed surfaces
 1. Unformed surfaces shall be classified as either:
 - a. U4, timber trowel finish
 - b. U3, steel trowel finish
 - c. U2, brush finished
 - d. U1, other finish designated by the Engineer.
 2. The type of finish will be specified on the drawings or as directed by the Engineer. Before beginning any concrete pour with unformed surfaces, the Contractor shall obtain confirmation of the type of finish required from the Engineer
 3. Initial finishing of unformed surfaces shall commence immediately after placing and compaction have taken place.

4. Suitable access boards or platforms shall be provided to allow access to all parts of unformed surfaces to be finished.
5. Where a protective treatment or topping layer is to be applied to the concrete the manufacturer's and supplier's recommendations shall be followed concerning the required finish.
6. Brush finish shall be obtained by carrying out a steel trial finish and then using a suitable stiff nylon brush dragged lightly across the surface.
7. The addition of small quantities of water to the finishing trowel will be permitted to aid finishing.

C. Formed surfaces

1. Finishes to formed surfaces of concrete shall be classified as F1, F2 and F3, or such other special finish as may be particularly specified.
2. Where the class of finish is not specified, all internal concrete shall be finished to Class F3 and external concrete below ground shall be finished to Class F1.
3. Where surfaces are covered with paint or sheeting, the formwork shall be capable of achieving a finish suitable for the proposed covering as approved by the Engineer.
4. Formwork for Class F3 finish shall be lined with as large panels as possible of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fibre board, arranged in a uniform approved pattern and fixed to back formwork by oval nails. The same type of lining shall be used throughout any one structure. Unfaced wrought boarding or standard steel panels shall not be permitted.
5. Formwork for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.
6. Formwork for Class F1 finish shall be constructed of timber, or any suitable materials which will prevent loss of grout when the concrete is vibrated.
7. Grooves in exposed concrete shall be formed by attaching tapered, planed timber battens accurately aligned, to the face of formwork.

D. Exposed Concrete Surface Finishes:

1. Exposed concrete surfaces shall have Class F3 finish.
2. Great care shall be taken to ensure that the finish to the exposed concrete on the external and internal surfaces is of the highest quality to produce a smooth concrete surface of uniform texture and appearance without visible imprint of grains, steppings or ridges.
 - a. Formwork to the wetted surfaces of water retaining structures shall be Class F3.
 - b. All exposed concrete corners and edges shall have 20 mm x 20 mm chamfers.

E. Form Ties: Form ties shall be; factory-fabricated; adjustable in length; removable or snap-off metal form ties; cone ends if required by the drawings; designed to prevent formwork deflection and to prevent the spalling of concrete surfaces on removal. No metal shall be left closer than 38 mm to the surface of the concrete. Ties shall not leave a hole larger than 10 mm diameter in the concrete surface, when using snap ties.

F. Form coatings shall be commercial formulation compounds that will not bond with, stain, nor adversely affect concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured.

G. Fillet/chamfer strips shall be PVC or timber to approval

- H. Tape shall be plastic faced adhesive tape to approval, to seal joints of formwork panels for smooth finish concrete.
- I. Precast concrete molds shall be rigid steel molds.
- J. Form release agent shall be a colorless material which will not stain concrete, nor absorb moisture. All form release agents must be compatible with all materials applied to concrete surfaces.
- K. Flashing reglets shall be galvanised steel, longest possible length, alignment splines for joints securable to formwork.

Part 3 Execution

3.01 Formwork Erection

- A. The Contractor shall be responsible for the calculations and designs for the formwork and shall submit them to the Engineer prior to the start of construction. Formwork to external faces which will be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the size of such panels shall be approved by the Engineer before they are used in the construction of the Works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by formwork and by construction joints to ensure continuity of horizontal and vertical lines.
- B. Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter. Form joints and tie holes shall be watertight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete. The Contractor shall verify lines, levels and measurement before proceeding with formwork. The Contractor shall ensure that the sides and bottom of earth forms are hand trimmed.
- C. Formwork shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal (except where such top surface is specified as spaded finish). The formwork shall be anchored to enable the concrete to be properly compacted and to prevent flotation, and care shall be taken to prevent air being trapped.
- D. Temporary openings for inspection of the inside of the formwork and for the removal of water used for washing down shall be provided and so formed as to be easily closed before placing concrete.
- E. Windows shall be provided in forms wherever directed or necessary for access for concrete placement and vibration. The windows shall be of sufficient size for tremies and vibrators to be placed, spaced at a maximum of 1.8m centres horizontally. Windows shall be tightly closed and sealed before placing higher concrete.
- F. Formwork in contact with the concrete shall be treated with suitable non-staining mold oil to prevent adherence of the concrete. Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall be used only where ordered by the Engineer. Release agents shall not be used where concrete surfaces receive special finishes or applied coatings which may be affected by agent, unless approved by the Engineer.
- G. The Contractor shall co-ordinate the work of other Sections in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchors and other inserts.

- H. Conduits or pipes shall be located so as not to reduce the strength of the construction. In no case shall pipes other than conduits be placed in a slab 125 mm in thickness. Conduits embedded in a concrete slab shall not have an outside diameter greater than $\frac{1}{3}$ the thickness of the slab nor be placed below bottom-reinforcing steel or over top-reinforcing steel. Conduits may be embedded in walls provided they are not larger in outside diameter than $\frac{1}{3}$ the thickness of the wall, are not spaced closer than 3 diameters on centre, and do not impair the strength of the structure. Embedded pipes and conduits shall be supported independently from reinforcing steel in a manner to prevent metallic contact and thereby prevent electrolytic deterioration. Pipes and conduits where embedded shall be placed as nearly as possible to the centre line of the concrete section. Conduits, piping, and other wall penetrations or reinforcements shall be subject to Engineer's review and approval.
- I. Position ties passing through concrete to approval of Engineer.
- J. Ties or bolts or other devices shall not be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer to the surface than the cover required for reinforcement. The surface of concrete shall be rubbed down smooth with carborundum and water in an approved manner within three days of removing the formwork and holes left after removal of such supports shall be neatly filled with non-shrink epoxy grout of suitable consistencies and matching color.
- K. Where part of a metal tie remains embedded in concrete, it shall not have less cover than reinforcement.
- L. Position chamfer-moulding strips on exposed corners of columns, and beams.
- M. Do not use surface retarding agents.
- N. Cambers: Cambers shall be as indicated on the drawings. The depth of beams at all points in the span shall also be as indicated.
- O. Strip formwork carefully to avoid sudden shocks from removal of wedges, or vibration which might damage concrete.
- P. Where finished surfaces have re-entrant angles, remove formwork as early as possible to avoid shrinkage cracks.
- Q. Place re-shoring to beams and slabs, immediately after stripping formwork.
- R. Where re-shoring is required for early stripping while minimising sag or creep, the capacity and spacing of such re-shores shall be adequate for the purpose.
- S. All exterior angles to concrete exposed to view in the completed structure shall be cast to the true angles evenly throughout the length. Great care shall be taken to ensure that no waviness occurs along the angle and that no spalling occurs to the concrete on removal of the formwork.
- T. Devices of the tell-tale type shall be installed on supported forms and elsewhere as required to detect formwork movements and deflection during concrete placement. The required slab and beam cambers shall be checked and correctly maintained as concrete loads are applied on forms. Workmen shall be assigned to check forms during concrete placement and to promptly seal all mortar leaks.
- U. Holes formed in concrete surfaces by formwork supports or the like shall be filled neatly with non-shrink epoxy grout. The Contractor shall clean any hole that is to be filled with non-shrink epoxy grout. Where the concrete surface has been damaged, any loose, broken or cracked concrete or aggregate shall be broken out. The concrete surrounding the hole shall be then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted with ordinary Portland cement by means of a small dry brush until the whole surface that

will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed. Grout material shall then be placed and packed in layers having a compacted thickness per manufacturer's instructions. Compaction shall be carried out by the use of a hardwood stick and a hammer and shall extend over the full area of the layer, with particular care being taken to compact the dry-pack against the side of the hole. After compaction, the surface of each layer shall be scratched before further loose material is added. The hole shall not be over-filled and the surface shall be finished by layering a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

V. Pipes through walls:

1. Pipes and pipe specials through concrete walls and floors shall as far as possible be positioned and built-in during construction and shall be located exactly in the positions shown on the drawings and shall be true to line and level.
2. The Contractor shall place orders for these items immediately after the Contract is awarded and shall make every effort possible to ensure early delivery to site. The supply and delivery of built-in pipework shall be clearly shown on the detailed construction program to be submitted by the Contractor.
3. The Contractor shall take particular care to ensure that fully compacted concrete is in contact with the pipe at all points.
4. Where it is not practicable to cast pipes and specials in the concrete, boxholes shall be formed in the formwork
 - a. The box shall have six or eight sides, depending on the pipe diameter, and shall be no larger in size than will give adequate clearance for the subsequent positioning and grouting in of the pipe.
 - b. The sides of the box hole shall be provided with a tapered central annular recess to provide a positive key and shall allow rebar to extend across the opening.
 - c. The boxhole shall be provided with a grout hole and, at the top of the central annular recess a vent hole.
 - d. The boxhole shall be stripped with the main shuttering and the concrete surface thoroughly cleaned and roughened.
5. When the pipe is later fixed, the remaining hole shall be re-formed and filled with non-shrink epoxy grout or non-shrink concrete. In the case of water-retaining structures the Contractor shall ensure that measures adopted shall provide a finished joint which is adequately strong and free from leakage.
6. In either case, the Contractor shall be solely responsible and all additional costs, if any, shall be borne by the Contractor.

3.02 Removal of Formwork

- A. The Engineer shall be notified prior to the removal of any formwork.
- B. Concrete shall be thoroughly wetted as soon as forms are first loosened and shall be kept wet during the removal operations and until curing media is applied.
- C. Potable water supply with hoses having fine fog spray attachments shall be ready at each removal location before operation are commenced.

- D. The period of time elapsing between the placing of the concrete and the striking of the formwork shall be approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown below:

Type of formwork	Minimum period before stripping (times are exclusive of the day of concrete placement)
Beam sides, walls and column	1 day
Soffits of slabs-props left under	4 days
Soffits of beams-props left under	10 days
Props to slabs	10 days
Props to beams	14 days

- E. Stripping of formwork within the time limits listed above does not relieve the Contractor from successfully crushing test cubes and achieving specified compressive strength results.
- F. Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

End of Section 03100

Section 03200: Concrete Reinforcement

Part 1 General

1.01 Description

The work includes furnishing, fabrication, and placement of reinforcement for cast-in-place concrete, including bars, welded wire fabric, ties, and supports.

1.02 Submittals

A. Submittal requirements shall conform to Section 01300.

B. Product Data

1. The Contractor shall provide the manufacturer's specification and installation instructions for proprietary materials and reinforcement accessories.
2. The Contractor shall furnish the manufacturer's records of chemical and physical properties of billet steel bars and a certificate that the respective material furnished meets the requirements for the steel reinforcement specified. The manufacturer's records shall include mill certificates as well as chemical analysis, tensile and bend tests.
3. Three copies of the steel test report shall be furnished with each consignment of steel reinforcement.

C. Shop Drawings

1. Detail fabrication and placement drawings for all reinforcing steel which are correlated with forming and concrete placement techniques and requirements.
 - a. Reinforcing steel shall be detailed based on construction joint locations which have been shown on shop drawings approved by the Engineer.
 - b. Drawings shall be in such detail as to ensure that there will be a minimum of difficulties, if any, in execution of the work in the field.
 - c. Drawings shall consist of sections, plans and details clearly showing locations, sizes, spacing and shapes of all reinforcing steel, caps and splices supporting bars and accessories.
 - d. Include bar bending schedules and diagrams to indicate bends, sizes and lengths of all reinforcement prepared in accordance with BS 4466.
2. A separate set of shop drawings, showing construction joint locations, shall also be submitted for approval and shall indicate all floor openings, wall openings and edges of concrete. Floor openings, wall openings, pipe inserts and sleeves for all mechanical, plumbing and electrical work shall be co-ordinated with the respective trades and shown on these shop drawings in accordance with the criteria indicated on the Contract Drawings.
3. No work shall be fabricated until both sets of shop drawings (Reinforcement and Concrete Dimensions) have been reviewed by the Engineer (with corrections and re-submittals as required by the Contract Documents). After approval approved by the Engineer, the Contractor shall furnish all copies needed for fabrication and erection, and for the use of other trades.

4. The Contractor shall be fully responsible for furnishing and installing all materials called for or required by the Contract Documents even though these materials may have been omitted from the reviewed shop drawings.
5. The approval of shop drawings, or revised bar schedules shall in no way relieve the Contractor of his responsibility for the correctness of such drawings or schedules.

D. Samples

1. Representative samples of all reinforcing steel that the Contractor proposes to use in the Works must be submitted to the Engineer for his written approval, before work is commenced. The Contractor shall submit manufacturer's certificates stating clearly for each sample:
 - a. place of manufacture,
 - b. expected date and size of deliveries to site
 - c. all relevant details of composition, manufacture, strengths and other qualities of the steel.
 - d. The Engineer reserves the right to sample and inspect all reinforcement steel upon its arrival at the work site.
 - e. The Contractor shall provide a certificate confirming that samples taken from the bars delivered to the works pass the re-bend test.
2. Frequency of sampling and the method of quality control shall be in accordance with Appendix C of BS 4449.

1.03 Delivery, Storage and Handling

A. Delivery

- B. Bars in each lot shall be legibly tagged by the manufacturer. The tag shall show the manufacturer's test number and lot number and other applicable data that will identify the material with the certificate issued for that lot of steel.
- C. Fabricator shall furnish three copies of a certification which shows the production numbers from which each size of bar in the shipment was fabricated.

D. Storage

1. Reinforcement shall be stored on suitable structures a minimum of 450 mm above the ground surface and covered to prevent damage and accumulation of dirt, rust and other deleterious matter.
 2. The storage facilities shall be such as to permit easy access for inspection and identification.
 3. Bundles of reinforcement shall be clearly tagged with bar schedule and bar mark reference and these shall not be removed until the material is at the location where it is to be incorporated into the works.
 4. Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, earth, paint, or any other material which may impair the bond between the concrete and the reinforcement.
- E. Reinforcement shall not be handled roughly, dropped from a height, or subject to shock loading or mechanical damage.

Part 2 Products

2.01 Materials

A. Reinforcing Steel:

1. Reinforcing steel shall conform to BS 4449 and shall have the following minimum yield strength. The yield strength of the reinforcing steel is defined as the stress corresponding to a strain of 0.35 percent, and shall correspond to that delivered by tests on full size bars.

<u>Bars</u>	<u>Yield Strength</u>	<u>Symbol</u>
Plain round mild steel	250 N/mm ²	R
Deformed high yield bars	460 N/mm ²	Y

2. All bars shall be sand blasted after fabrication. After fixing and immediately prior to placing of concrete the reinforcement shall be pressure-washed with fresh water.
- B. Welded steel wire fabric shall conform to BS 4483. Welded intersections shall not be spaced more than 310 mm for plain round bars or 400 mm apart for deformed high yield bars in direction of calculated stress except when used as stirrups.
 - C. Tie wire shall conform to BS 4482. No wires smaller than size D-4 shall be used.
 - D. Spacers shall be made of concrete, metal, or other as approved by the Engineer.
 - E. Welding, if permitted by the Engineer, shall conform to the requirements of AWS D 1.4 or BS 5135

2.02 Testing of Reinforcement Steel

- A. Tests shall be carried out in strict accordance with BS 4449 and at the discretion of the Engineer from time to time.
- B. Tensile tests providing information on the following will be required from each lot delivered:
 1. elastic limit,
 2. ultimate strength,
 3. stress-strain curve,
 4. cross-sectional area,
 5. deformation/bond characteristics of deformed bars
- C. The Contractor shall allow for all tensile, bond, re-bond and chemical tests for each size of bar to be used in the concrete construction. Test results for each bar size shall be submitted to the Engineer in accordance with the requirements of Section 01300. Further tests may be called for when the source of supply of reinforcement changes. When any test results do not conform to the relevant standard, the reinforcement steel shall be removed from the Site.

Part 3 Execution

3.01 Installation

- A. General
 1. All reinforcement shall be securely and accurately fixed in positions shown on the Drawings to ensure that the reinforcement steel framework as a whole shall retain its shape. The reinforcement framework shall be so temporarily supported as to retain its correct position in the forms during the process of depositing and consolidating the concrete.

2. The ends of all tying wires shall be turned into the main body of the concrete and not allowed to project towards the surface.
3. No part of the reinforcement shall be used to support access ways, working platform or for the conducting of an electric current.
4. Specific attention is drawn to the following general requirements:
 - a. lapped joints shall be as indicated on the Drawings and/or in accordance with the requirements of BS 8110.
 - b. hooks shall be semi-circular with a straight length of at least four bar diameters for mild steel and six diameter for high yield steel.

B. Welding

1. Welding shall not be permitted unless authorised by the Engineer and recommended by the reinforcement manufacturer.
2. Welding shall be executed under controlled conditions in a factory or workshop.
3. Welding on site shall not be permitted unless suitable safeguards and techniques are employed and the types of steel have the required welding properties.
4. Welding if approved, may be used for:
 - a. Fixing crossing or lapping reinforcement in position;
 - b. Fixing bars to other steel members;
 - c. Structural welds involving transfer of loads between reinforcement or between bars and other steel members.
5. Lap welding between bars is not permitted.
6. Make butt welds by flash butt welding or metal-arc welding. Other methods may be approved, subject to their satisfactory performance in trial joints.
7. Metal-arc welding or electrical resistance welding may be used for fixing suitable steels or for lapped joints.
8. Flash butt welding shall be executed with the correct combination of flashing, heating, upsetting and annealing, using only machines which automatically control this cycle of operations.
9. Metal-arc welding shall comply with AWS D1.4 and the recommendations of the reinforcement manufacturer.
10. Welded joints cannot be used to make bends in reinforcement.
11. Weldable reinforcement where shown on the Drawings shall conform to ASTM A706.

- C. Mechanical splices shall be submitted for approval and shall comply with BS 8110. Their use shall be as indicated on the structural drawings.
- D. Bundling and splicing of bars shall be in accordance with BS 8110. Splicing, except where indicated on the Drawings or approved shop drawings, will not be permitted without the approval of the Engineer.
- E. The Engineer shall be notified at least 24 hours before commencing fixing reinforcement for inspection of formwork. Spaces to receive reinforcement shall be thoroughly cleaned.
- F. Reinforcement shall not be fixed or placed in contact with non-ferrous metals.
- G. Correct concrete cover to reinforcement shall be maintained with the aid of approved spacer pieces. Concrete cover to any and all reinforcement shall be a minimum of 60 mm unless a larger cover is detailed on the Drawings.
- H. Spacers, chairs and other supports shall be provided as necessary to maintain reinforcement in its correct position. Spacer bars of same diameter as longitudinal bars,

but not less than 25 mm diameter, shall be fixed between the two layers at 1.5m centres, except where bundled bars are detailed.

- I. Placing of all reinforcement will be checked by the Engineer and in no case is concrete to be placed around any reinforcement that has not been approved by the Engineer. Insertion of bars into or the removal of bars from concrete already placed will not be permitted. Reinforcement temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer.
- J. Forms and linings shall not be damaged when fixing reinforcement.
- K. Reinforcement shall not be fixed until after the placing of any concrete lining protection.
- L. The position of reinforcement prior to and during placing concrete shall be checked. Particular attention shall be given to the position of top reinforcement in cantilever sections. Reinforcement shall be clean and free from corrosive pitting, loose rust, loose mill scale, oil and other substances which may adversely affect reinforcement, concrete, or the bond between the two. Projecting reinforcement shall be protected from the weather where rust staining of exposed concrete surfaces may occur. At the time of concreting, all reinforcement shall have been thoroughly cleaned and freed from all mud, oil or any other coatings that might destroy or reduce the bond. Immediately prior to concrete placing the reinforcing steel shall be washed thoroughly with high-pressure potable water jets to remove any deposited salts.

3.02 Fabrication

Reinforcement shall not be cut and heated to bend into shape. Cut and bent reinforcement shall be to bar schedules and details, unless otherwise instructed. The Contractor shall provide on-site facilities for hand-bending of small rebar only to deal with approved minor adjustments. All bending shall be done cold with the use of an approved bending machine.

3.03 Field Quality Control

- A. Inspection of reinforcing steel and the installation thereof will be conducted by the Engineer. The Contractor shall give 24-hour notice to the Engineer before closing forms or placing concrete.
- B. The Engineer may instruct the Contractor to break out and remove completely all sections of the work already constructed under any of the following circumstances.
 - 1. reinforcing steel sample under test fails to meet the specification requirements at any time,
 - 2. the Engineer considers that samples which were presented to him for test were not truly representative,
 - 3. it becomes apparent that reinforcing steel, which has not been approved, has been used on the Works.

End of Section 03200

Section 03300: Cast-in-place Concrete

Part 1 General

1.01 Description

- A. The Contractor shall furnish all materials and construct structures of the forms, shapes, dimensions and elevations shown on the Drawings, and as specified.
- B. The work includes furnishing all materials and facilities necessary for producing, placing, curing and finishing cast-in-place concrete.
- C. The Contractor shall use Portland cement for construction of the Works.

1.02 Definitions

- A. Water/Cement Ratio: the ratio by weight of water to cement in a mix, expressed as a decimal fraction. Water being that which is free to combine with cement, including free water in aggregate but excluding that absorbed by the aggregate.
- B. Hot Weather: a shade air temperature of 37° C. and rising.
- C. Construction Joint: a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement. The surface where two successive placements of concrete meet, across which it is desirable to develop and maintain bond between the two concrete placements and through which any reinforcement which may be present is not interrupted.
- D. Movement Joints: a joint intended to accommodate movement between adjoining parts of a structure, special provision being made where necessary for maintaining the watertightness of the joint. Typical movement joints provided are: expansion joints; complete contraction joints; partial contraction joints; sliding joints.
- E. Expansion Joint: a separation between adjoining parts of a concrete structure which is provided to allow small relative movements such as those caused by thermal changes to occur independently.
- F. Contraction Joint: formed, sawed, or tooled groove in a concrete structure to create a weakened plane and/or to regulate the location of cracking resulting from the dimensional change of different parts of the structure.
- G. Control Joint: as contraction joint.
- H. Fair Face Concrete: a concrete surface which, on completion of the forming process, requires no further (concrete) treatment other than curing (See also architectural concrete).
- I. Architectural Concrete: concrete which will be permanently exposed to view and which therefore requires special care in selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.
- J. Water retaining structure: any structure or any part of which will contain water or process liquids, or which protects spaces from groundwater.

1.03 Submittals

- A. Product Data
 - 1. Cement:
 - a. source of cement shall be subject to the Engineer's approval

- b. manufacturer's test sheets shall be supplied with each consignment of cement certifying compliance with the relevant standard
 - c. the Contractor shall submit the date of manufacture and proof that the specifications have been complied with, certified by an independent agency in the country of origin.
 2. The Contractor shall submit details of proposed aggregate sources for approval by the Engineer.
 3. The Contractor shall submit details of proposed water source for approval by the Engineer. the details shall include the chemical analysis and a certificate from an independent testing agency that the specifications have been complied with.
 4. The Contractor shall submit the manufacturer's technical recommendations and specifications for any additives proposed.
 5. Current test reports and written certificates for waterstops, joint filler board, joint sealant and primer, slip membrane, sealing strip membrane and repair materials shall be submitted to the Engineer for review and approval.
- B. During the mobilisation period the Contractor shall submit for the approval of the Engineer a method statement detailing his proposals for the organisation of concreting activities for each structure or type of structure. The method statements shall be approved before any concrete is placed. Any alteration in the source of quality or proportioning of any of the materials in the mix will necessitate a new method statement. Method statements shall be prepared for each grade and type of concrete in the Contract and shall include, but not limited to, the following details:
1. plant proposed,
 2. layout of concrete production facility,
 3. proposed method for production of concrete,
 4. quality control procedures for concrete and concrete materials,
 5. transport and placing of concrete including the use of chutes, conveyor belts or pumps as a means of transporting concrete.
- C. Shop Drawings shall follow the requirements detailed in Section 01300. The Contractor shall submit shop drawings showing the proposed layout of all construction joints; details for the installation of waterstops in movement joints including location of joints, intersections and changes of direction with cross sections; consolidated shop drawings showing all mechanical penetrations.
- D. Samples
1. Slide bearings: The Contractor shall provide at least three samples of material proposed, including the manufacturer's technical specifications, application recommendations, and anticipated performance.
 2. Slip joints: The Contractor shall provide at least three samples of materials proposed including manufacturer's technical specifications, application recommendations, and anticipated performance.
 3. Waterstops & membranes: The Contractor shall provide at least three samples of proposed types, including prefabricated joints and junctions, if applicable. If joints are to be made up on site, provide worked samples including samples for each make of waterstop and membrane, where different manufacturers are used.
 4. Cement samples shall be provided from each consignment delivered to the Site as required by the Engineer for testing.
 5. Aggregate: The Contractor shall provide samples of both fine and coarse aggregates to the Engineer for testing. Samples shall be taken in the presence

of the Engineer or Engineer's representative. Aggregate samples shall be provided at least one month prior to beginning deliveries to site.

- E. Trial mixes: for each grade and type of concrete in the contract and shall include:
1. Definition of the method of design of the mix, by reference to a recognised published design method.
 2. Designed aggregated proportions shall be based on measured and not assumed relative densities.
 3. Proposed mix proportions including any proposed admixture and for new batching installations, results of preliminary batch testing.
 4. Results of testing of trial mixes to demonstrate that the proposed mix complies with the strength and workability requirements of this specification.
 5. For concrete mix designs which include an admixture, trial mixes shall be prepared and tested both with and without the admixture to give a clear indication of its effects on the physical characteristics of the mix.
- F. In addition to the scheduling and programming requirements specified in other sections, the Contractor shall submit to the Engineer for his approval as soon as practicable, and not less than thirty days before commencement of concreting on a structure, a program detailing concrete placement sequences. The programme shall include details of: estimated time for pours; size of each pour; time of commencement and finish. If it is likely that placing of concrete will conflict with paragraph 3.06 'B' herein, then approval of the program will not be given.

1.04 Ready-mixed Concrete

- A. The use of ready-mixed concrete in any part of the Work shall require the Engineer's written approval and all sections of Specification 03300 also apply to ready-mixed concrete. The Contractor shall satisfy the Engineer on the following:
1. materials used in ready-mixed concrete comply with the specification in all respects
 2. manufacturing and delivery resources of the proposed supplier are adequate to ensure proper and timely completion.
- B. The specified requirements as to the submittals, sampling, trial mixing, testing and quality of concrete, of various grades as herein, shall apply equally to ready-mixed concrete. Every additional facility, including but not limited to testing equipment, labour, laboratory facilities and transport, which the Engineer or persons authorised by him may require for the supervision and inspection of the batching, mixing, testing and transporting to Site of ready-mixed concrete shall be provided by the Contractor at no extra cost.
- C. A copy of the delivery note shall be given to the Engineer's site representative for each load. Copies of all delivery notes shall be submitted to the Engineer in duplicate, on computer generated forms and shall include at least the following information.
1. name of supplier, serial number of ticket and date
 2. truck number
 3. name of Contractor
 4. name of Contract and location of office
 5. grade of concrete
 6. specified workability
 7. type and source of cement
 8. source of aggregate

9. nominal maximum size of aggregate
 10. quantity of each concrete ingredient
 11. type of admixture and quantity
 12. water content
 13. time of loading and departure from ready-mix plant
 14. arrival and departure times of truck
 15. time of completion of discharge
 16. notations to indicate equipment was checked and found to be free of contaminants prior to batching.
- D. Unless approved otherwise in advance of batching all concrete of single design mix for any one day's pour shall be from a single batch plant of a single supplier. Ready-mix concrete shall conform to BS 5328, except materials, testing and mix design shall be as specified in this Section. Transit mixers equipped with automatic devices for recording the number of revolutions of the drum shall be used. Excess water over the maximum allowed by the mix design shall not be added. Each mixer truck shall arrive at the job site with its water container full. In the event that a container is not full or concrete tests give a greater slump than acceptable, the load shall be rejected. No water shall be added at the Site.
- E. Shade temperature and concrete temperature shall be recorded at the point of discharge of the mixer and at placement for each load of concrete delivered to site. Maximum and minimum temperatures and wet bulb temperatures shall be recorded daily.
- F. Slump tests shall be performed in accordance with BS 1881 at the point of placement for each load delivered to the Site.

1.05 Delivery, Storage and Handling

A. Delivery:

1. Cement shall be delivered in the manufacturer's bulk containers or in the original sealed and branded bags, bearing the manufacturer's name, cement type and date of manufacture, in batches not exceeding 100 tonnes.
2. Ready-mixed concrete delivery ticket shall record the actual batched weight of ingredients and the time of addition of water.

B. Storage:

1. Cement: Immediately upon arrival at the Site, cement shall be stored in silos designed for the purpose, or dry, weather-tight and properly ventilated structures with floors raised 450 mm above ground level with adequate provision to prevent absorption of moisture. All storage facilities shall be subject to approval by the Engineer and shall be such as to permit easy access for inspection and identification. A free passage of at least one metre shall be left between the cement and the sidewalls of the structure. Each consignment of cement shall be kept separately and the Contractor shall use the consignments in the order in which they are received. In no case shall bagged cement be stored in stacks more than eight bags high. Different types of cement shall be kept in clearly marked separate storage facilities. Cement delivered to the Site in drums or bags provided by the supplier or manufacturer shall be stored in the drums or bags until used in the Works. Any cement in drums or bags which have been opened shall be used immediately. Where site limitations preclude the storage of

cement on site, cement shall be stored at a central location and shall be delivered daily as required to specific job sites. The Contractor shall provide weighing machines which shall be kept permanently in each shed for checking the weight of the bags or barrels of cement. The Engineer shall have access at all times to the cement storage sheds. 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. Any consignment of cement not used within two months from the date of manufacturer, and cement, which in the opinion of the Engineer is of doubtful quality, shall not be used in the Works until it has been re-tested and test result sheets showing that it complies in all respects with the relevant standard have been delivered to the Engineer.

2. Aggregate: The Contractor shall provide a means of storing the aggregates at each point where concrete is made such that:

- a. each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times;
- b. contamination of the aggregates by the ground or other foreign matter shall be effectively prevented at all times;
- c. each stockpile of aggregate shall be capable of draining freely;
- d. storage shall be such as to prevent segregation;
- e. stockpiles shall be on hard and clean surfaces with not more than five per cent slope.

Coarse aggregate shall be stockpiled in two separate gradings of 20 to 10 mm and 10 to 5 mm. Stockpiling is not necessary where a crushing-screening plant is used in tandem with a batching plant. Preparation, siting and size of stockpiles, and methods of segregation shall be to the approval of the Engineer.

3. Chemical curing compounds shall be stored in accordance with manufacturer's recommendations.

- C. Handling: Ready-mixed concrete: trucks shall be discharged within the approved period after addition of water to cement. Trucks still containing any concrete after the approved expiry time shall be rejected. The rejected concrete shall be disposed of in a legal manner.

Part 2 Products

2.01 Concrete Mix

- A. Grades of concrete to be used in the Works shall be as shown below. The criteria given are designed to produce a workable homogenous plastic mixture and to ensure a long service life under the particular exposure conditions at the site. Where adequate workability is difficult to obtain at the maximum water/cement ratio allowed, an increased cement content and/or the use of plasticizers or water-reducing admixtures may be considered at no additional cost to the Employer. Cement contents in excess of 400 kg/cu. m shall not be used unless special consideration has been given to reduce thermal stress in the concrete.

Concrete	Max. Size	Min. Cement	Max. Free Water/Cement	Cube Crushing at 28 days	Trial Mix	Works
Grade	Agg.	Content	Water/Cement			

	mm	kg/m ³	nt Ratio	N/mm ²	Test N/mm ²
40	20	370	0.45	50	40
35	20	350	0.45	45	35
30	20			40	30
20	20	310	0.60	30	20

- B. Blinding concrete shall be grade 20 unless otherwise specified and thickness shall be as shown on the Drawings but in any case not less than 75 mm thick.
- C. No-fines concrete shall be made using a coarse natural aggregate conforming to BS 882 and cement to BS 4027. No fines aggregate shall be used. Grading of the coarse aggregate shall be not less than 95 percent by weight passing a 20 mm BS sieve and not more than 5 percent by weight passing 10 mm BS sieve. The proportions of aggregate, cement and water shall be determined by trial mixes by the Contractor starting with cement: aggregate ratio of one to eight by volume. All the aggregate particles shall be coated with a film of cement grout. The water content shall be just adequate to ensure that the cement paste completely coats the aggregate. No-fines concrete when placed shall contain no layers of Latinate. No-fines concrete shall not be mixed by hand. Vibration shall not be used to compact the no-fines concrete. Three test cubes of no-fines concrete shall be made of each preliminary mix. Minimum crushing strength of the chosen mix shall be 15 N/sq mm at 28 days. Porosity is such that water will pass through a slab 300 mm thick at the rate of not less than 7 litres/sec/m² of slab with a constant 100 mm depth of water on the slab. Where a slab incorporating vertical weep holes or drain holes is cast above a layer of no-fines concrete any polyethylene sheeting shall be pierced below the pipes forming such drain holes and the edges of the sheeting sealed to the lower end of the pipe to prevent the ingress of grout and fine particles from the slab concrete into the no-fines concrete.
- D. Design of Concrete Mixes: At the commencement of the Works the Contractor shall design a mix for each grade of concrete listed above that is required to be constructed on the Works. The Contractor shall submit full details of the mix designs to the Engineer for approval. For concrete using other than sulphate resisting Portland cement, or incorporating admixtures, the strengths shall not be less than those specified above, but the mix designs shall be revised and agreed with the Engineer. Each mix design shall be such that:
1. aggregate shall comprise fine aggregate and coarse aggregate of the maximum size specified,
 2. combined aggregate grading shall be continuous,
 3. aggregate quantity shall be calculated by weight,
 4. mixes shall be designed to produce a concrete cube strength at twenty eight days after manufacture of not less than the cube strength specified above.

2.02 Portland Cement Concrete

Consists of a mixture of Portland cement, fine aggregate, coarse aggregate, water, and additives (when required). The proportion, mix and placing shall be in accordance with BS 5328 and BS 8110 for framed building structures and BS 8007:1987 for water retaining structures.

Where these specifications conflict with, or are inconsistent with, the requirements of BS 5328/BS 8110/BS 8007, the requirements in these specifications shall prevail. Specific design requirements shall be as defined in these specifications. All concrete mixes shall be designed for special or ordinary concrete as defined in BS 8110, Clause 6.3.

2.03 Cement

- A. The specification requirements for ASTM cement types I, II, III, IV and V and ordinary Portland cement, rapid hardening Portland cement, sulphate resisting Portland cement and low heat cement are:

Compound		ASTM Type					BS 12		BS 4027BS	
		I	II	III	IV	V	OPC	RHP	SRP	low
Silica, S, (SiO ₂)	≥	-	21.	-	-	-	-	-	-	-
Alumina, A, (Al ₂ O ₃)	≤	-	6.0	-	-	-	-	-	-	-
Ferric Oxide, (Fe ₂ O ₃)	≤	-	6.0	-	6.5	-	-	-	-	-
Magnesia (MgO)	≤	6.0	6.0	6.0	6.0	6.0	4.0	4.0	4.0	4.0
Sulphur trioxide (SO ₃)										
When tricalcium aluminate ≤8%	≤	3.0	3.0	3.5	2.3	2.3	-	-	-	-
When tricalcium aluminate ≥8%	≤	3.5	-	4.5	-	-	-	-	-	-
When tricalcium aluminate ≤5%	≤	-	-	-	-	-	2.5	3.0	-	2.5
When tricalcium aluminate ≥5%	≤	-	-	-	-	-	3.0	3.5	2.5	3.1
Loss of ignition	≤	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Insoluble residue	≤	0.7	0.7	0.7	0.7	0.7	1.5	1.5	1.5	1.5
Tricalcium silicate (C ₃ S)	≤	-	-	-	35.	-	-	-	-	-
Dicalcium silicate (C ₂ S)	≥	-	-	-	40.	-	-	-	-	-
Tricalcium aluminate (C ₃ A)	≤	-	8.0	15.	7.0	5.0	-	-	3.5	-
Tetra calcium aluminoferrite C ₄ AF+2(C ₃ A)	≤	-	-	-	-	20.	-	-	-	-
C ₃ A for moderate sulphate resistance	≤	-	-	8.0	-	-	-	-	-	-
C ₃ A for high sulphate resistance	≤	-	-	5.0	-	-	-	-	-	-
C ₃ S+C ₃ A for moderate heat of hydration	≤	-	58.	-	-	-	-	-	-	-
Alkalis (NaO ₂ +0.658K ₂ O)	≤	0.6	0.6	0.6	0.6	0.6	-	-	0.6	-
For low alkali cement										

Note: Abbreviations commonly used to describe compounds and oxides present in Portland cement:

A	alumina	C ₂ S	dicalcium silicate	F	ferric oxide
C	lime	C ₃ S	tricalcium silicate	H	water
C ₃ A	tricalcium aluminate	C ₄ AF	tetracalcium aluminoferrite	S	silica

			ASTM Type					BS 12		BS 4027 SRPC	BS 1370 low heat
			I	II	III	IV	V	OP C	RHP C		
Setting Time (min)	≥		45	45	45	45	45	45	45	45	60
Initial											
(Vicat test) (h)	≤		8	8	8	8	8	10	10	10	10
Final											
(Gillourne test) (min)	≥		60	60	60	60	60	-	-	-	-
Initial											
(h)	≤		10	10	10	10	10	-	-	-	-
Final											
Fineness											
Air Permeability	≥		28	28	-	28	28	225	325	250	27
(m ² /kg)											
Turbidimeter (m ² /kg)	≥		16	16	-	16	16	-	-	-	-
Soundness											
Autoclave expansion	≤		0.8	0.8	0.8	0.8	0.8	-	-	-	-
(%)											
Le Chatteler (mm)	≤		-	-	-	-	-	10	10	10	10
Compressive strength (Mpa)≥											
mortar	1 d		-	-	12.	-	-	-	-	-	-
cubes	3 d		12.	10.	24.	-	8	23	29	20	10
	7 d		19.	17.	-	6.9	15	-	-	-	-
	28		-	-	-	17.	20	41	46	39	28
Concrete	3 d		-	-	-	-	-	13	18	10	5
cubes	28		-	-	-	-	-	29	33	27	19
Heat of Hydration	≤										
(kJ/kg)											
(1 cal/g = 4.2kJ/kg)	7 d		-	29	-	25	-	-	-	-	250
	28		-	33	-	29	-	-	-	-	290

B. Ordinary Portland cement and rapid hardening Portland cement shall meet the requirements of BS 12. Low heat Portland cement shall conform to the requirements of BS 1370. Sulphate resisting Portland cement shall conform to the requirements of BS 4027. Portland blast furnace cement and low heat blast-furnace cement shall conform to the requirements of BS 146. Different brands or types of cement shall not be mixed together for use in the works

C. ASTM cement types I, II, III, IV and V shall meet the requirements of ASTM C-150.

D. The testing of cement shall be carried out in accordance with the provisions of BS 4550 Parts 2 and 3

- E. Any cement which is, in the opinion of the Engineer, unsuitable for use in the Works shall be rejected and the Contractor shall promptly remove such cement from the Site.

2.04 Aggregates

A. General

1. Shall consist of tough, hard durable and uncoated particles containing no harmful material in quantities sufficient to adversely affect the concrete or reinforcing steel.
2. Shall comply with the requirements of BS 882 except as modified hereunder and shall be washed clean with potable water, if necessary to comply with these requirements.
3. Contractor shall provide all data as specified in Appendix A of BS 882.
4. Contractor shall satisfy the Engineer that the aggregates to be supplied will not give rise to an alkali reaction with the cement.
5. Should have a low coefficient of thermal expansion.
6. Sampling and testing of aggregates shall be carried out in accordance with the requirements of the appropriate section of BS 812.
7. Both River Sand and Crushed Rock Materials are acceptable for Fine Aggregate provided they satisfy the required particles grading in accordance with the British Standard.
8. Beach sand shall not be permitted for use in concrete mixes.
9. Aggregates shall meet the requirements of Table A.
10. Frequency of routine testing of aggregates shall be in accordance with Table B.
11. Mineralogical tests are to be carried out as and when directed by the Engineer.
12. No aggregate deliveries shall be made to the site until the Engineer has approved the samples as complying with these specifications.
13. Samples of aggregates will be tested at intervals during construction of the works and the Contractor shall provide the necessary equipment and labour.

TABLE A

Requirement		Test Methods		Permissible Limits	
		BS 812	ASTM	FINES	COARSE
1.	Grading	Part 103 (dry)		Standard	Standard
2.	Material finer than 0.075 mm	Part 103		max. 3%	Max. 1%
	Natural, uncrushed/ Crushed	(wet)			
	Crushed rock			max. 5%	Max. 3%
3.	Clay lumps and friable particles		C142	max. 3%	Max. 2%
4.	Light weight pieces		C123	max. 0.5%	Max. 0.5%
5.	Organic impurities		C40	Colour standard not darker than Plate No. 3	
6.	Water absorption		C128/C127	max. 2%	Max. 2%
7.	Specific Gravity (apparent)		C128/C127	min. 2.6	Min. 2.6
8.	Shell content:	Part 106			
	Coarser than 10 mm				Max. 3%
	Between 5 mm & 10 mm				max. 3%
	Between 2.36 mm & 5 mm Finer than 2.36 mm			max. 10%	
				Note 1	

	Requirement	Test Methods		Permissible Limits	
		BS 812	ASTM	FINES	COARSE
9.	Particle shape: Flakiness index	Part 105.1			Max. 25%
	Elongation index	Part 105.2			Max. 25%
10.	Acid Soluble Chlorides:	Part 117,			
	A. For reinforced concrete with:	Appendix C			
	SRPC			max. 0.06%	Max. 0.03%
	OPC & MSRPC			max. 0.06%	max. 0.03%
	B. For mass concrete made with:				
	SRPC			Max. 0.06%	Max. 0.03%
	OPC & MSRPC			Max. 0.06%	max. 0.03%
	C. For prestressed & Steam cured structural concrete			max. 0.01%	Max. 0.01%
11.	Acid Soluble Sulphates	Part 118		max. 0.3%	Max. 0.3%
12.	Soundness, (MgSo4 - 5 Cycles		C88	max. 10%	Max. 10%
13.	Mechanical Strength:10% fines value	Part 111			Min 120 kN
	Aggregate Impact value	Part 112			Max. 40%
	Loss Angeles Abrasion value		C131/C535		Max. 45%
14.	Drying Shrinkage	Part 120			Max. 0.05%
15.	Potential reactivity: Note 2 Of Aggregates, Chemical Method Of Cement-Aggregate Combination		C289	Not Reactive	Not Reactive
			C227	6 month expansion max.	0.10%

Note 1: There is no requirement of shell content in sands passing 2.36 mm sieve size.

Note 2: Aggregates may initially be assessed for its reactivity in accordance with ASTM C289 and if potential reactivity is indicated, then mortar bar tests in accordance with ASTM C227 shall be carried out.

TABLE B

	Requirement	Test Method	Test Frequency
1.	Grading	BS 812 : Part 103	Each 2 weeks or per 100 m ³ which ever is more frequent
2.	Material finer than 0.075 mm	BS 812 : Part 103	-do-
3.	Clay lumps and Friable Particles	ASTM C 142	-do-
4.	Organic Impurities	ASTM C 40	Each month or per 200 m ³ whichever is more frequent
5.	Water Absorption	ASTM C128/C127	-do-
6.	Specific Gravity	ASTM C128/C127	-do-
7.	Shell Content	BS 812 : Part 106	Each 2 months or per 100 m ³ whichever is more frequent
8.	Particle Shape	BS 812 : Part 105.1 & 105.2	-do-
9.	Acid Soluble Chlorides, Cl Quantitative Quantitative	BS 812 : Part 117, Appendices A/B BS 812 : Part 117, Appendix C	On each delivery to site Each week, if result is more than 75% of the limit and each month if result is less than 75% of the limit.
10.	Acid Soluble Sulphates, S03	BS 812 : Part 118	Each two weeks if result is

Requirement		Test Method	Test Frequency
11.	Soundness (Mg S04 - 5 cycles)	ASTM C88	more than 75% of the limit & each two months if result is less than 75% of the limit. Each month.
12.	Mechanical Strength		
	10% Fines or Impact Value	BS 812 : Parts 111/ 112	Each month
	Los Angeles Abrasion	ASTM C 131/C 535	-do-
13.	Moisture variation in sand - by Moisture Meters		Twice daily
14.	Drying Shrinkage	BS 812 : Part 120	At the start of the project and whenever there is a change in the source of supply.
15.	Potential Reactivity:	ASTM C295/C289	At the start of the project and wherever there is a change in the source of supply.
	Of aggregates	ASTM C586	
	Of carbonate	ASTM P124/C227	
	Of cement aggregate combination		

2.05 Fine Aggregate for Concrete and Mortar

Fine Aggregate Grading

BS 410 Test Sieve	Percentage Weight Passing BS Sieves		
	Zone 1	Zone 2	Zone 3
mm			
10.00	100	100	100
5.00	90-100	90-100	90-100
2.36	60-95	75-100	85-100
1.18	30-70	55-90	75-100
µm			
600	15-34	35-59	60-79
300	5-20	8-30	12-40
150 (natural sands)	0-10	0-10	0-10
150 (crushed rock)	0-20	0-20	0-20

- Gradation shall be in accordance with BS 882 excluding grading designation F. Fine aggregate shall be clean, sharp, natural and/or crushed sand.
- Each batch of aggregate delivered to site shall be kept separate from previous batches and shall be stored for at least three working days before use to allow inspection and tests to be carried out.
- The Contractor shall mechanically wash aggregate to remove salts and other impurities in order to meet the requirements specified.

2.06 Coarse Aggregates for Concrete

- A. Coarse aggregates shall be prepared as single sized aggregate and blended to produce normal size grading. Combined grading shall be within the appropriate grading limits given in BS 882.
- B. Aggregates that are deliriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of concrete shall not be used.
- C. The Contractor shall mechanically wash aggregate to remove salts and other impurities in order to meet the requirements specified.

Coarse Aggregate Grading

BS 410 Test Sieve	Percentage Weight Passing BS Sieves							
	Nominal Size of Graded Aggregate			Nominal Size of Single Sized Aggregate				
	40 mm to 5 mm	20 mm to 5 mm	14 mm to 5 mm	63 mm	40 mm	20 mm	14 mm	10 mm
mm								
75.5	100	-	-	100	-	-	-	-
63.0	-	-	-	85-100	100	-	-	-
37.5	95-100	100	-	0-30	85-100	100	-	-
20.0	35-70	95-100	100	0-5	0-25	85-100	100	-
14.0	-	-	90-100	-	-	-	85-100	100
10.0	10-40	30-60	50-85	-	0-5	0-25	0-50	5-100
5.0	0-5	0-10	0-10	-	-	0-5	0-10	0-25
2.36	-	-	-	-	-	-	-	0-5

2.07 Combined Aggregate

- A. Approved coarse aggregate and fine aggregate in each batch shall be combined in proportions as specified in BS 882 and as approved by the Engineer.
- B. In no case shall materials passing the 0.05 mm sieve exceed three percent by weight of the combined aggregate.
- C. Combined aggregate gradation used in the work shall be as specified, except when otherwise approved or directed by the Engineer.
- D. Changes from gradation to another shall not be made during progress of the work unless approved by the Engineer.

2.08 Water

- A. Water used for concrete-mixes, washing of equipment, wetting of surface or ponding during curing or for wetting formwork and washing reinforcement shall be potable water and shall comply with the requirements of BS 3148 except as modified hereunder. The Contractor shall make his own arrangements and obtain approval for the supply of water.
- B. The pH of water used in concrete works shall be not less than 6 or more than 7.5.
- C. The temperature of water for concrete shall not be less than 5° C nor more than 25° C. Water may be cooled to not less than 5° C by the gradual addition of chilled water or

ice. No ice particles shall be present in the mix. Ice to be used shall be crushed and shall be product of frozen water which complies with acceptance criteria as follows:

	Test Method	Limits
Compressive strength, min. % control at 7 days	ASTM C109	90
Setting time, deviation from control, h:min	ASTM C191	from 1:00 early to 1:30 later
Chloride (as Cl)	ASTM D512	250 mg/l
Sulphates (as SO ₃)	ASTM D516	350 mg/l
Alkali carbonates and bicarbonates	ASTM D513	500 mg/l
Total dissolved ions, including above	ASTM D1888	2000 mg/l
pH	-	7 - 9

- D. Every effort should made to protect water pipes and tanks from the sun, e.g., burying, shading, insulation or painting white.
- E. Water for curing concrete shall not contain impurities in sufficient amounts to cause discolouration of the concrete. Source of water shall be maintained in such a manner as to exclude silt, mud, grass and other foreign matter.
- F. Whenever required to do so by the Engineer the Contractor shall take samples of the water being used or which it is proposed to use for mixing concrete and test them for quality. Samples of water not less than 5 litres shall be taken, sealed and sent for testing at an approved independent laboratory prior to the approval of any water source and periodically during the continuance of its use.
- G. Water of questionable quality should comply with the physical and chemical limitations listed above.
- H. No source of water shall be used until the required tests have demonstrated its suitability for concreting.

2.09 Admixtures

- A. Admixtures shall mean materials added to the concrete materials during mixing for the purpose of altering the properties of the concrete mix.
- B. Where approved and or directed by the Engineer, admixtures shall be used as a means of increasing concrete durability; increasing workability of the concrete without increasing the water/cement contents; or controlling and limiting retardation of setting.
- C. Admixtures shall comply with the requirements given below:

Water Reducing Admixture	ASTM C494	Type A
Retarding Admixture	ASTM C494	Type B
Water Reducing, high range and retarding admixtures	ASTM C494	Type G

- D. The methods of use and the quantities of admixture used shall be subject to the Engineer's approval and shall in no way limit the Contractor's obligations under the contract to produce concrete with the specified strength, workability and durability.
- E. In addition to the standard requirements for approval of materials, approval of admixtures shall be subject to extensive trials to demonstrate the suitability, adequacy of dosing arrangements and performance.

- F. The Contractor shall provide sufficiently large capacity in his concrete producing plant and concrete transporting arrangements and use an appropriate admixture to avoid cold joints. The Contractor shall be entirely responsible for the use of any approved admixture at no additional cost to the Employer and in strict accordance with the Manufacturer's instructions.
- G. The Contractor shall provide the following data and ensure that the product complies with the following specifications:
1. Admixtures which comply with ASTM C494 Type G shall be employed to:
 - a. Produce highly flowable and self compacting concrete at the lowest possible water cement ratio or as specified.
 - b. Produce a consistency of concrete that is free of bleeding and segregation.
 - c. Provide slump retention and set control as and when applicable.
 - d. Offer the user impermeability and durability.
 2. Admixture shall be based on naphthalene sulphonates. Where deemed necessary lignosulphonate admixtures conforming to ASTM C494 Type B may also be employed providing this is to the satisfaction of the Engineer.
 3. No admixtures containing chlorides shall be used.
 4. The use of the admixtures shall be controlled i.e. strict quality control to ensure correct dosages as prescribed by the manufacturer are used. Admixture is to be dispensed by a transparent unit which enables the operator to see the discharge.
 5. Concrete supplier shall furnish a series of at least 10 trial mixes which clearly indicate that the use of the admixture has consistently exhibited the specified absorption, permeability and pouring values. These are to be verified by an approved independent laboratory. The concrete supplier shall also conduct (with the above) a trial showing that a control mix without the admixture does not exhibit a greater density than that incorporating the admixture.
- H. Hydrophobic Pore Blocking Admixtures: If in the opinion of the Contractor a hydrophobic pore-blocking admixture is required to achieve the requirements specified herein, the Contractor may use an admixture based on ammonium stearates and hydrocarbon resin at no additional cost to the Employer. The admixture is to be added at a rate of 30 litres/m³ at the time of mixing. The manufacturer's representative is to be present for all additions of the hydrophobic pore blocking compound to ensure correct dosage rates are used. Admixture shall be Febproof Marine or Caltile or approved equal.

2.10 Water Stops

- A. Materials shall be sourced and supplied by a single manufacturer with a minimum of ten years experience. The manufacturer shall operate a quality system which is registered to ISO 9001. Technical back-up service during installation to be provided by the manufacturer at no additional cost to the Employer.
- B. PVC or nitrile rubber waterstops shall be extruded from a high grade elastomeric polyvinyl chloride compound which contains plasticizers, resin stabilizers and other materials necessary to meet the performance requirements of this specification. Rubber and PVC waterstops shall be suitable for storage, handling, installation and service within a range of 15°C to 50°C.

- C. PVC waterstops shall be manufactured from PVC to BS 2571, or approved equal and shall not contain recycled or filler material. The minimum tensile strength shall be 15 N/mm². Elongation at break shall be minimum 300 percent and Shore A hardness shall be 75-90. The waterstop shall be fully continuous and coordinated four bulbed sections. Testing shall be carried out in accordance with BS 2782, US Corps of Engineers specification CRD C572-74 or relevant ASTM methods.
- D. Rubber waterstops shall be to US Federal Specification 22R-601a, except that compression shall be to ASTM D395-52 and hardness shall be to ASTM D676. Minimum tensile strength shall be 20.7 N/mm² and elongation at break shall be minimum 450 percent.
- E. Waterstop intersection & transition pieces shall be pre-formed and/or prefabricated factory moulded type. Joints shall be heat sealed using the manufacturer's recommended welding equipment.
- F. External waterstops for base slab expansion joints shall be minimum 225 mm wide with minimum of two bulbs and parallel lines of fins. Centre section shall be 25 mm wide and flat to accept a filler board. It shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shutter with double headed nails and shall be provided with an additional key when cast into the concrete.
- G. External waterstops for base slab construction and contraction joints shall be minimum 225 mm wide with minimum of two bulbs and parallel lines of fins and shall incorporate a central fin, as a shutter stop. They shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shutter with double headed nails and shall be provided with an additional key when cast into the concrete.
- H. Internal waterstops for wall and roof expansion joints shall have a centre box to accommodate movement and shall be minimum 225 mm wide with four bulbs and parallel lines of fins. The centre section shall be flat to accept a filler board. The web shall be 10 mm thick with a thickened central section to transfer stresses to the centre bulbs. The waterstop shall have a reinforced eyelet outer flange for secure fixing of the waterstops into position.
- I. Internal waterstops for wall and roof construction and contraction joints shall be minimum 225 mm wide with minimum of two bulbs and parallel lines of fins. The web shall be 100 mm thick with a thickened central section to transfer stresses to the centre bulbs. The waterstop shall have a reinforced eyelet outer flange for secure fixing of the waterstop into position.
- J. Water bars shall be arranged so that there is a minimum distance of 25 mm from the water bar to the reinforcement. Waterstops shall not be nailed or damaged in any way. The Contractor shall ensure that the concrete surrounding the waterstop is fully compacted without the waterstop being displaced. Waterstops shall be WRC approved for use in contact with potable water.

2.11 Movement Joints

- A. AJoint fillers shall be non-absorbent, semi rigid, closed cell, heat laminated polyethylene filler board and shall be non-tainting in accordance with BS 6920. They shall be fully compatible with the surface sealants and if elastometric sealants are used the joint filler shall act as a bond breaker. Performance properties of the joint filler shall be as follows:

Recovery	Greater than 98% after 50% compression
Extrusion	Nil (three edges restrained and sample compressed by 50%)

Density	100 kg/m ³ ± 5 kg/m ³
Water	less than 1%
Absorption	

- B. Joint sealants shall be two part polysulphide complying with BS 4254 and must, in all cases, be carefully selected as appropriate for their climatic and environmental exposure. Where appropriate, they shall be resistant to biodegradation. Movement capacity of the sealant must be at least 20 percent of the joint width. The Contractor must apply written recommendations and guarantees from the manufacturers as to the suitability of the product for each individual structure and the method of installation. Primers shall have no harmful effects on concrete. Where required, masking tape shall be applied to protect the concrete surface on either side of the joint during priming and sealing operations. Masking tape must be stripped carefully away after joint sealing to leave near edges to the seal. Sealant shall be Feb Masterflex 700 or approved equal.
- C. Primer shall be as recommended by the sealant manufacturer.
- D. Bond breaker shall be forced, non-absorbent polyethylene backing strip or equals as recommended by sealant manufacturer to prevent adherence of sealant to backup material.

2.12 Accessories

- A. Vapour barrier/separation layer shall comprise two layers to underside of blinding concrete and ground slabs of gauge 1000 clear polyethylene sheets conforming to ASTM C 171. The physical properties for materials shall conform to ASTM E154.
- B. Non-shrink grout shall be as specified in Section 03600.
- C. Slip membrane shall be preformed low friction bearing strip to form a thin sliding joint with a minimum bearing capacity of 0.7 N/mm². It shall be extruded from specially formulated polyethylene to form a durable lamina, resistant to most chemicals, solvents and weathering. It shall be applied in two layers with bottom layer bonded to substrate with high quality solvent borne adhesive based on polychloroprene rubber. The thickness shall be 1.5 mm minimum. Coefficient of static friction shall be 0.15 and it shall be suitable for operating temperatures up to 50°C.
- D. Sealing strip membrane: Where indicated on the Drawings, expansion joints shall be sealed with a sealing strip system. The joints shall be pre-sealed using sealant prior to laying sealing strip membrane. The sealing strip system shall comprise of hypalon high-polymer flexible sheeting bonded to the concrete surfaces on either side of the joint using suitable epoxy resin adhesive. The system proposed shall have high performance and shall allow considerable movements in more than one direction while maintaining a high quality seal. The width of the flexible membrane shall be 250 mm and the minimum thickness shall be 3 mm. The minimum unbonded width of the membrane shall be 50 mm, centred on the joint, to allow greater movement potentials. Masking tape shall be applied to achieve the required debonded width. The final sealing strip system shall be able to accommodate movement which results in the debonded area being extended up to 100 percent of the debonded width. The performance properties shall be:

Density	~1.65 kg/litre (adhesive) ~1.50 kg/m ² (hypalon /mm)
Service Temperature	~30°C to +70°C
Application Temperatures	Type Normal min. 10°C Type Rapid 5°C to 15°C

Bond Strength to Concrete	Dry or Damp $\approx 4 \text{ N/mm}^2$ (concrete failure)
Bond Strength to Steel	$\sim 6 \text{ N/mm}^2$ (strip failure)
Tensile Strength	$\sim 6 \text{ N/mm}^2$
Peel Strength	$\sim 4,5 \text{ N/mm}^2$
Elongation	$>400 \%$

- E. Liquid membrane forming curing compounds shall be ASTM C309 approved standard product; shall be fugitive-dye resin or silicone type, free of wax or oil and shall be compatible with subsequently applied finished or coverings. They shall not be deleterious to bond of cementitious materials to concrete and shall be delivered in unopened labelled containers.
- F. Curing sheet materials shall conform to ASTM C171 and shall be waterproof paper, polyethylene film or white burlap-polyethylene sheet and be non-staining.

Part 3 Execution

3.01 Trial Mixes

- A. As soon as the Engineer has approved the concrete mix design for each grade of concrete and during or following the carrying out of the preliminary tests the Contractor shall prepare a trial mix of each grade in the presence of the Engineer at least 35 days before commencement of concreting.
- B. Trial mixes shall be mixed for the same time and handled by means of the same which the Contractor proposes to use in the Works. Each mix shall be not less than 0.5 cu m of concrete.
- C. The proportions of cement, aggregate and water shall be carefully determined by weight in accordance with the Contractor's approved mix design (or modified mix design after preliminary tests). Sieve analyses shall be made, by the method described in BS 812, of the fine aggregate and of each nominal size of coarse aggregate used.
- D. The slump of each batch of each trial mix shall be measured immediately after mixing by the method described in BS 1881 and shall be within the limits as specified.
- E. Contractor shall make three separate batches for each trial mix and six 150 mm compression test cubes shall be made from each batch in the presence of the Engineer. Temperature, workability and density of concrete in each batch shall be determined. Three cubes shall be tested at seven days and three at 28 days, after manufacture in accordance with the method described in BS 1881. If the average value of the strength of the nine cubes tested at 28 days is less than the trial mix strength given in Table 3.3, and/or the difference between the greatest and the least strengths is more than 20 percent of the average strengths, the Contractor shall remove from site, materials from which the trial mix was prepared and shall provide new materials and prepare and test further trial mixes until specified requirements are achieved.
- F. A full scale test of the workability of each trial mix of each grade of concrete shall be made by the Contractor in the presence of the Engineer. Trial mixes of each grade of concrete shall be batched, mixed and then transported a representative distance in the manner that the Contractor proposes to batch, mix and transport the concrete to be placed in the Works. After discarding the first batch so made, the concrete from later batches shall be placed and compacted in trial moulds both for reinforced and mass concrete with dimensions typical of the Works in accordance with the procedures described in later clauses. The sides of the moulds shall be capable of being stripped

without undue disturbance of the concrete placed therein. The sides of the moulds shall be stripped after the concrete has set and the workability judged on the compaction obtained. If the workability test shows that the workability required is not attained for any trial mix for any class of concrete, the trial mix shall be re-designed by the Contractor. A further full-scale workability test shall be undertaken for that trial-mix of concrete.

- G. Re-design of the concrete mixes, and the making and testing of preliminary and trial mixes of concrete, shall be repeated for each grade of concrete until trial mixes of concrete meet the specified requirements and have the workability required to place it in the Works as demonstrated in the full scale workability test described above.
- H. The Contractor shall only use the approved mix of each grade of concrete in the Works. If, at any time during the construction of the Works, the source of cement or aggregate is changed, or the grading of the aggregate alters to such an extent that the fraction of aggregate retained on any sieve cannot be maintained within two percent of the total quantity of fine and coarse aggregate when adjusted in accordance with paragraph 3.01 here-in, then further trial mixes of concrete shall be made, tested and approved for use. Preliminary laboratory tests shall be carried out to determine the mixes to satisfy the specification with the approved materials. Trial mixes shall be tested to determine the following properties of mixes proposed for initial field tests. If the values obtained are unacceptable, the mixes shall be re-designed:
 - 1. bleeding in accordance with ASTM C232 (non-vibrating) shall not exceed 0.5 percent
 - 2. shrinkage in accordance with BS 1881:Part 5 or BS 6073:Part 1 Appendix D
 - 3. air content to BS 1881: Part 106.
 - 4. free water/cement ratio
 - 5. workability to BS 1881:Part 102.
 - 6. fresh and hardened concrete densities to BS 1881:Parts 107 and 114 respectively.
 - 7. compressive strength to BS 1881:Part 116
 - 8. water permeability to DIN 1048 shall be maximum 10 mm at 28 days and maximum 15 mm at 7 days.
- I. Approval of the job-mix proportions by the Engineer or his assistance to the Contractor in establishing those proportions, in no way relieves the Contractor of the responsibility of producing concrete which meets the requirements of these Specification.
- J. The Engineer may also require practical tests to be made on the Site by filling trial moulds to confirm the suitability of:
 - 1. mix for the works,
 - 2. type of plant used for mixing,
 - 3. method of compaction used,
 - 4. formwork face intended for use in the works.
- K. All costs connected with the preparations of trial mixes shall be borne by the Contractor.
- L. Whenever a change of brand or source for any of the concrete ingredients occurs, additional "preliminary tests" will be required and the cost of these tests shall be borne by the Contractor.

3.02 Measurement of Ingredients

- A. All cement used in the manufacture of concrete shall be measured by weight either with an approved weighing machine or by making the size of each batch of concrete such as to require an integral number of complete bags or drums of cement.
- B. In concrete of Grade 20, the fine and coarse aggregates shall be measured separately by weigh batching machines which shall provide facilities for the accurate control and measurement of the materials either singly or cumulatively. The machines shall be capable of immediate adjustment by semi-skilled operators in order to permit variations to be made to the mix. All weight dials shall be easily visible from the place at which filling and emptying of the hoppers are controlled.
- C. Every concrete-mixing machine shall be fitted with a water-measuring device which shall be so constructed that the inlet and outlet valves are interlocked so that either one of them cannot be opened unless the other is fully closed. The device shall be provided with an overflow with a cross-sectional area at least four times that of the outlet pipe and with its discharge point clear off the mixing plant. The entire water system shall be maintained free of leaks at all times. The measuring device shall be fitted with a drain pipe which allows the full quantity of water being measured to be drained off for checking the measurement. The outlet arrangements of the measuring device shall be such that between five and ten percent of the water enters the mixer before the other materials and a further five to ten percent of the water enters the mixer after the other materials. The remainder of the water shall be added at a uniform rate with the other materials. It shall also be readily adjustable so that the quantity of water added to the mixer can, if necessary, be varied for each batch. Arrangements for cooling of the mixing water shall be approved by the Engineer.
- D. Any admixtures which may be used shall be measured separately in calibrated and transparent dispensers. Admixture shall be added to the mixture with the water. The dispenser shall be capable of dispensing the agent in quantities varying by not more than 5 percent from the quantities required and in such a manner to ensure uniform distribution of the agent throughout the batch during the time of mixing. The capability of the dispenser to achieve the required dosing and mixing requirement shall be demonstrated to the Engineer and shall be checked each day before concrete mixing commences.
- E. The amount of concrete mixed in any one batch shall not exceed the rated capacity of the mixer and the whole of the batch shall be removed before materials for a fresh batch enter the drum. On cessation of work, including all stoppages exceeding twenty minutes, the mixers and all handling plant shall be washed with clean water. All mixing and batching plants shall be maintained free of set concrete or cement and shall be clean before commencing mixing.
- F. Contractor shall provide weights, containers and equipment necessary for testing the accuracy of the weighing plant, water-measuring plant and admixture dispenser.
- G. The batching plant shall be calibrated each month.
- H. Hand mixing of concrete is not allowed.

3.03 Mixing of Concrete

- A. All structural concrete to be placed in-situ shall be manufactured in a computer controlled batching plant. If necessary, the plant shall be complete with suitable water chilling and ice making facility to ensure concrete temperatures are maintained as specified. Batching and mixing concrete off-site shall only be with prior approval. Mixing

and transporting of concrete produced off-site shall be in accordance with the requirements of ready mixed concrete BS 5328. Concrete shall be mixed in batches in plant capable of combining the aggregates, cement and water (including admixtures, if any) into a mixture of uniform colour and consistency and of discharging the mixture without segregation. On commencing work with a clean mixer the first batch shall contain only half the normal quantity of coarse aggregate to compensate for the adhesion of the other materials to the drum. The natural moisture contents of the aggregates shall be determined before the commencement of each day's concreting and at such intervals during each day as may be necessary. The Contractor shall make due allowance for the water contained in the aggregates when determining the quantity of water to be added to each mix and the amount of water added to each mix shall be adjusted to maintain the constant approved water/cement ratio of the mixed concrete. No concrete shall exceed the specified water/cement ratio. The quantity of water used in mixing 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.

- B. The use of ready-mixed concrete in any part of the Work shall require the Engineer's written approval. The Contractor shall satisfy the Engineer that materials used in ready-mixed concrete comply with the Specification in all respects and manufacturing and delivery resources of the proposed supplier are adequate to ensure proper and timely completion. The specified requirements as to the sampling, trial mixing, testing and quality of concrete of various grades shall apply equally to ready-mixed concrete. Every additional facility, including transport, which the Engineer or persons authorised by him may require for the supervision and inspection of the batching, mixing, testing and transporting to Site of ready-mixed concrete shall be provided by the Contractor. Each load shall be accompanied by a bonded weigh-master's certificate listing those items listed in Section 1.04 A 5 herein. A copy of the certificate shall be given to the Engineer's site representative for each load. Unless approved otherwise in advance of batching all concrete of single design mix for any one day's pour shall be from a single batch plant of a single supplier. Ready-mix concrete shall conform to BS 5328, except materials, testing and mix design shall be as specified herein. Transit mixers equipped with automatic devices for recording the number of revolutions of the drum shall be used. No water shall be added during transporting to site or at the site. Each mixer truck shall arrive at the job site with its water container full. In the event that a container is not full or concrete tests give a greater slump than acceptable the load shall be rejected. Shade temperature and concrete temperature shall be recorded at the point of discharge of the mixer and at placement for each load of concrete delivered to site. Maximum and minimum temperatures and wet bulb temperatures shall be recorded daily. Perform slump tests in accordance with BS 1881 at the point of placement for each load delivered to site. Test cement in accordance with BS 4027 or ASTM C150 for each delivery of cement. Tests of cement and aggregates shall be performed to ensure conformance with requirements specified.
- C. Test reports for all concrete shall be submitted at weekly intervals giving test results for workability and strength. For trial mixes the following data shall be submitted:
1. slump,
 2. strength at 7 days and 28 days,
 3. maximum aggregate size,

4. unit weight of concrete mix,
5. water/cement ratio and quantity; water content, water adjustment,
6. type of cement and dosage,
7. type of Admixture and dosage,
8. gradation of coarse and fine aggregate,
9. combined coarse and fine aggregate ratio,
10. ratio of fine to coarse aggregate,
11. percentage of absorption for coarse and fine aggregate, based on saturated surface dry material,
12. volume of batch for trial mix.

3.04 Concrete Testing

A. Preliminary (Trial) Test

1. Target mean strength: The concrete mix shall have at least the required minimum cement content and mean strength greater than the required characteristic strength by at least the current margin. The current margin shall be taken as the lesser of:
 - a. 64 times the standard deviation of cube tests on at least 100 separate batches of concrete of nominally similar proportions of similar materials and produced over a period not exceeding 12 months by the same plant and under similar supervision, but not less than one sixth (1/6) of the characteristic strength for concrete of Grade 15 or not less than 3.75N/mm² for concrete of Grade 20 or above.
 - b. 1.64 times the standard deviation of cube tests on at least 40 separate batches of concrete of nominally similar proportions of similar materials and produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision, but not less than one third of the characteristic strength for concrete of Grade 15 or not less than 7.5 N/mm² for concrete of Grade 20 or above.
 - c. If enough data are not available to satisfy the requirements of either (a) or (b) above, the margin shall be taken as two-thirds of the characteristic strength for concrete of grade 15 or 10 N/mm² for concrete of Grade 20 or above. When required characteristic strength approaches maximum possible strength of concrete a smaller margin but not less than 7.5 N/mm² shall be permitted. Evidence shall be submitted to the Engineer for each grade of concrete showing that at the intended workability the proposed mixed proportions and manufacturing method will produce concrete of the required quality.
2. To establish the suitability of any material used in the concrete work, unless specified otherwise, the Contractor shall make preliminary tests and prepare design mixes, in accordance with BS 5328, in a design laboratory acceptable to the Engineer.
3. In addition to the tests required to establish the suitability of materials, the Contractor shall make one test for each design mix to verify that the total chloride ion content and the total sulphate (SO₃) content of each mix is within the specified limits. Chloride tests shall be performed in accordance with BS 812:Part 117 and sulphate (SO₃) tests in accordance with BS 812:Part 118. Chloride and sulphate levels in the concrete mix shall comply with the following requirements:

Type of Concrete	% by wt. of Cement	
	Chlorides as Cl	Sulphates as SO ₃
For reinforced concrete		
if made with OPC/MSRPC	max 0.30	max 3.70
if made with SRPC	max 0.06	max 3.70
Pre-stressed concrete and heat-cured reinforced concrete	Max 0.10	max 3.70
For mass concrete		
if made with OPC/MSRPC	Max 0.60	max 3.70
if made with SRPC	Max 0.12	max 3.70

Note:

- a. *OPC and MSRPC cements can also contain chlorides, the relevant standard BS 12 allows up to 0.1 percent of chloride ion.*
 - b. *Any chloride content present in the cement has to be taken into account while computing total chloride ion in the mix.*
 - c. *In case the cement contains the maximum limit of 0.1 percent of chloride ion then the aggregates, water and admixtures used for pre-stressed concrete or heat cured reinforced concrete should absolutely free of chlorides.*
 4. When the results of a sufficiently large number of tests show that the previously established margin is significantly too large or too small, a change in the current margin used for judging compliance with the specified characteristic strength may be appropriate. Recalculation of the margin shall be carried out as before, but the adoption of recalculated value will not generally be justified if the two values differ by less than 18 percent when based on tests on 40 separate batches or 11 percent when based on tests on 100 separate batches, or 5 percent when based on tests on 500 separate batches. This recalculated margin, if adopted, becomes the current margin for the judgement of compliance with the specified characteristic strength of concrete
- B. Under the supervision and direction of the Engineer the Contractor will take specimens, as per BS 1881, of each class of concrete from different locations on the site. Each set of cubes shall be made at the point of placement. For each grade of concrete a set of six works test cubes shall be made whenever the Engineer may require and not less frequently than as follows:
1. for concrete Grade 35 or above one set of cubes per 30 cubic metres or part thereof, concreted per day,
 2. for concrete Grade 20 one set of cubes per 40 cubic metres or part thereof, concreted per day.
- C. Works Test Cubes
1. Take test cubes as specified from fresh mixed concrete which is being used in the Works and which has been prepared in the normal way.
 2. Cubes shall be numbered consequently and marked with the date, section of work from which they are taken and any other relevant information.
 3. Take at least six cubes for each sampling and test 3 at 7 days and 3 at 28 days.
 4. Strength of cubes shall be not less than the minimum strength requirements for each type of concrete.
 - a. If the average strength of the three works test cubes fail at 7 days:
 - b. immediately stop all concreting until checks are made on material and equipment, immediately rectify any defect which has become apparent as the result of checking,

- c. at Contractor's option, defective concrete may be removed and replaced without awaiting the 28 day test results.
5. If works test cubes fail at 28 days as specified in paragraph 3.11 herein:
 6. suspend concreting operations and do not proceed further without approval,
 7. take test cores in accordance with BS 1881: Part 120, or conduct insitu load tests in accordance with BS 1881: Part 124 on suspect work, in the presence of the Engineer,
 8. replace all defective work,
 9. re-testing shall be executed to the Engineer's approval.
- D. Two cylinders shall be cast to determine the tensile strength of the concrete at 7 days and 28 days, as specified in BS 1881: Part 117. Samples shall be taken from every 100 batches, but at least once a week during concreting operations and shall coincide with samples taken for test cubes.
- E. Concrete shall be tested for durability properties by undertaking absorption and permeability tests where appropriate, or directed by the Engineer, as directed below:
1. Water absorption tests shall be carried out in the laboratory on 75 mm diameter cores cut at an age of 24 to 28 days to enable the tests to be carried out between 28 and 32 days in accordance with BS 1881: Part 122. Upper acceptable limit for absorption after 30 minutes shall be one percent.
 2. Permeability tests shall be in accordance with the method described in DIN 1048 and the maximum acceptable penetration at seven days shall be 10 mm.
- F. Other Tests
1. When instructed by the Engineer, concrete shall be tested for drying shrinkage and wetting expansion. 75 x 75 mm prisms shall be prepared for testing in accordance with Test 5 of BS 1881: Part 5 or BS6073: Part 1, Appendix D. The maximum acceptable limits shall be 0.05 percent for drying shrinkage and 0.03 percent for wetting expansion.
 2. Additional cubes may be required and trials carried out to determine stripping times for formwork; duration of curing and to check testing and sampling errors.
 3. Air content of air-entrained concrete shall be determined in accordance with ASTM C231 for each batch produced until consistency has been achieved, when batches may be tested. The maximum value shall not exceed one percent.
- G. Workability shall be assessed by the tests mentioned hereunder and shall be carried out as required during concreting of permanent works to control workability at the batching plant and at the site of pour. The degree of workability shall be as for the trial mixes and permitted tolerances shall be in accordance with BS 5328. Slump test shall be performed according to BS 1881: Part 102 (at site of pour) and the allowable slump shall be 150 - 175 mm. Compaction factor tests shall be performed according to BS 1881: Part 103 (at site laboratory) and the allowable limit shall be 0.85 - 0.92. Vebe time shall be performed according to BS 1881: Part 104 (at site laboratory). Flow test shall be performed according to BS 1881: Part 105 (at site laboratory).

3.05 Transporting Concrete

- A. Transportation, delivery and handling shall be as specified in BS 5328. Concrete shall be conveyed from the mixer to its place in the Works as rapidly as possible by methods which will prevent segregation or drying-out. The Contractor shall ensure that concrete is of the required workability at the point and time of placing. If segregation has nevertheless occurred in any instance the materials shall be remixed to the satisfaction

of the Engineer or discarded. The Contractor shall be responsible for the concrete being placed and compacted within such a time from the addition of the water to the mixer that the previous lift of concrete has not commenced setting.

- B. Tolerances shall be to BS 5606 for concrete construction and materials.
- C. The Contractor shall record time, date, temperature and slump of all concrete at the mixer and point of placement. The Contractor shall render to the Engineer, not more than twenty-four hours in arrears, a daily return for each grade of concrete comprising:
 - 1. number of batches mixed,
 - 2. number of batches and total volume of concrete placed,
 - 3. number of batches wasted or rejected,
 - 4. weight of cement and admixtures used.

3.06 Placing Concrete

- A. No concrete shall be placed until the Engineer has inspected and approved the surfaces upon which the concrete is to be placed, the formwork and the reinforcing steel. The Contractor shall give the Engineer not less than 24 hours to enable this inspection to be carried out. If concrete is not placed within 24 hours of approval being given, approval shall be obtained again before concreting. An inspection shall be made immediately prior to concreting to check the cleanliness of the forms. None of the requirements of this specification shall relieve the Contractor of his responsibility to place in the Works only sound well-compacted concrete free from voids and cracks.
- B. The Contractor's staff approved to supervise concrete work shall be on site whenever such work is executed.
- C. Before placing concrete, the Contractor shall remove from the surface of the foundations or previously placed concrete all oil, Latinate, loose fragments of rock, earth, mud, timber and other debris, and standing water to the satisfaction of the Engineer. Unless otherwise specified or directed by the Engineer, all excavated surfaces are to be covered with blinding concrete Grade 20 not less than 75mm thick.
- D. A vapour barrier separation layer shall be installed on the underside of blinding concrete and ground slabs on grade as specified. Lap joints shall be minimum 100 mm on sides and ends and the barrier shall not be disturbed while placing reinforcement.
- E. Concrete dropped into place in the Work shall be dropped vertically. It shall not strike the formwork between the point of its discharge and its final place in the Work. Except by prior approval of the Engineer, concrete shall not be dropped freely through a height greater than 1.5 m. Chutes and conveyor belts shall be also designed so that there is no segregation or loss of mortar. They shall be provided with a vertical tapered down pipe, or other device, to ensure that concrete is discharged vertically into place. When pumps are used, the end of the supply pipe shall be kept immersed in the concrete during placing to assist compaction. Concrete shall be carefully placed in horizontal layers which shall be kept at an even height throughout the Work. Concrete shall not be allowed to slide or flow down sloping surfaces directly into its final position but shall be placed in its final position from skips, trucks, barrows, down pipes or other placing machines or devices. If this is impossible, it shall be shovelled into position, care being taken to avoid separation of the constituent materials. Concrete placed in horizontal slabs from barrows or other tipping vehicles shall be tipped into the face of the previously placed concrete.
- F. Mortar or water used at the beginning or end of a run shall be discharged outside the formwork.

- G. Where concrete abuts against earth or any other material liable to become loose or to slip, care shall be taken to avoid falls of materials on to the surface of the wet concrete by suitable means.
- H. Concrete toppings shall be placed on top of structural slabs where indicated using a max. size aggregate of 10 mm, applied over an epoxy bonding agent. All toppings to be steel trowel finished as specified in Section 03320.
- I. During the placing of all reinforced concrete, a competent steel fixer shall be in attendance on each concreting gang. He shall ensure that the reinforcement and embedded fittings are kept in position as work proceeds.
- J. Whenever instructed by the Engineer, the Contractor shall carry out the work in such a manner that the placing of the concrete in any particular section of the structure shall be executed without any interruption whatsoever from the beginning to the end of the operation. Concrete floor and inverts shall be cast in one layer unless where specified otherwise, or when written approval has been obtained to use an alternative construction method.
- K. Care shall be taken to prevent men engaged in placing concrete from introducing foreign matter into the concrete from their boots or in any other way. Where concrete, is placed directly against the surface of excavations any softened material shall first be removed. Disturbance of freshly finished concrete shall be prohibited.
- L. The Contractor shall take precautions to prevent the temperature of concrete rising above 32°C. The concrete temperature shall be maintained at, or below 32°C, until it has hardened, and shall be shaded from direct sunlight to the satisfaction of the Engineer. Concrete shall not be mixed or placed when the ambient shade temperature exceeds 40°C and rising or 43°C on a falling thermometer. The times at which concreting will be allowed to take place will be agreed with the Engineer. The Contractor shall take the following precautions in hot weather:
 - 1. Cool water to between 5°C and 8°C.
 - 2. If ice is used take account in computing water/cement ratios and ensure that ice is melted before the concrete leaves the mixer.
 - 3. Cool aggregate with draughts and protect from sunlight with heat reflecting covers.
 - 4. Cool formwork and reinforcement:
 - 5. Use mixed concrete without delay.
 - 6. Do not expose wet concrete, or concrete carrying vehicles to the hot sun for more than the minimum practicable time.
 - 7. Insulate the rotating mixer drum externally to prevent overheating of the metal and excessive heat transfer.
 - 8. Any additional recommendations of ACI-305, BS 5328 and Cement and Concrete Association advisory note on "Hot Weather Concreting".
 - 9. Concrete shall be placed and compacted before initial set has occurred and in any event not later than sixty minutes from the time of mixing unless otherwise approved by the Engineer.
- M. Placing Concrete in Water
 - 1. No concrete shall be placed in flowing water.
 - 2. Underwater concrete shall be placed in position by tremis, or by pipeline from the mixer.
 - 3. Full details of the method proposed shall be submitted in advance to the Engineer and his approval obtained before placing begins.
 - 4. Where the concrete is placed by the tremis, its size and method of operation shall be in accordance with BS 8004.

5. During, and after, concreting under water, pumping or dewatering operations in the immediate vicinity shall be suspended until the Engineer permits them to be continued.

3.07 Compacting Concrete

- A. Except for slabs less than 100 mm thick, all concrete placed insitu shall be compacted with power-driven internal type vibrators supplemented by hand spading and tamping. Unless otherwise agreed by the Engineer slabs less than 100 mm thick shall be compacted by approved vibrating screeds. Vibrators shall at all times be adequate in numbers, amplitude and power to compact the concrete properly and quickly throughout the whole of the volume being compacted to the satisfaction of the Engineer. Spare vibrators shall be readily on hand in case of breakdown.
- B. Internal type vibrators shall be inserted into the un compacted concrete vertically and at regular intervals. Where the un compacted concrete is in a layer above freshly compacted concrete, the vibrator shall penetrate vertically for about 100 mm into the previous layer. Vibrators shall not come into contact with the reinforcement or the formwork and shall be drawn back slowly from the mass concrete so as to leave no voids. Internal type vibrators shall not be placed in the concrete in a random or haphazard manner nor shall concrete be moved from one part of the work to another by means of the vibrators.
- C. Compaction shall commence as soon as there is sufficient concrete to immerse the vibrator and continued during the placing operations so that at no times shall there be a large volume of un compacted concrete in the formwork.
- D. The duration of vibration shall be limited to that required to produce satisfactory compaction without causing segregation. Vibration shall, on no account, be continued after water or excess grout has appeared on the surface.

3.08 Curing of Concrete

- A. Immediately after compaction, and for a continuous minimum period of 14 days thereafter, concrete shall be protected from the harmful effects of weather, including rain, dry winds rapid temperature changes, premature drying and resulting effects of thermal shrinkage. Curing to be in accordance with ACI 301 chapter 12 and as modified here-under. The Contractor shall obtain approval of curing methods.
- B. Formed surfaces, including the undersides of girders, beams, supported slabs and the like, shall be cured by moist curing with the forms in place for the full curing period, or until forms are removed. When forms are stripped, curing shall be continued by any applicable specified method.
- C. Unformed surfaces shall be cured initially by moist curing and finally by any applicable specified method, unless otherwise indicated.
- D. Moisture curing shall be executed by covering surface with water and keeping continuously wet; fine fog water sprays in continuous operations; covering surface with a saturated absorptive cover and keeping continuously wet. The absorptive covers shall be placed with 100 mm laps, to cover the entire surface and edges.
- E. Moisture retaining cover curing shall comprise a suitable cover to the concrete surface. The cover shall be in the widest practicable widths and shall have 200 mm side and end laps and shall be sealed with waterproofing tape or adhesive. The Contractor shall immediately repair any holes or tears in the cover with cover material and waterproof tape.

- F. Liquid membrane curing shall be an approved non-staining, membrane forming curing compound in accordance with the manufacturer's recommendations and shall be applied immediately after any water sheen which may develop after finishing has disappeared from the surface and within two hours of stripping formwork on formed surfaces. Curing compound shall have a minimum 95 percent moisture retention standard. It shall not be used on surfaces against which additional concrete, or other material is to be bonded, unless it is proven that the curing compound will not prevent bond, or that positive measures are taken to remove it completely from those areas which are to receive bonded applications.
- G. Steam curing shall be carried out in an enclosure around the concrete using tarpaulin or other suitable means. Application of steam shall not commence until at least two hours after final placement of concrete. Steam shall be applied at a maximum temperature between 65°C and 80°C and the maximum steam temperature shall not rise above 82°C. Excessive rates of heating and cooling shall be prevented during steam curing and temperatures in the enclosure shall not increase or decrease by more than 22°C per hour. The maximum steam temperature shall be maintained in the enclosure until concrete has reached its specified strength.
- H. Backfill shall not be placed over concrete surround to pipes for a minimum of six hours after completion of concreting and dewatering equipment shall continue in operation for at least this period. Compaction of backfill over the pipe surround concrete shall not commence until at least 48 hours after completion of concreting.

3.09 Joints

- A. Construction joints shall comply with BS 5328 except as modified here-in. Waterstops are not considered necessary in properly formed construction joints. If the contractor wishes to install water stops in construction joints to satisfy the requirements of these Specifications, then water stops shall comply with these Specification and Drawings, the cost of which shall be borne by the Contractor. The Contractor shall submit detailed proposals not less than three weeks before the commencement of concreting and the details shall include the sequence of placing concrete; sizes of concrete pours; positions of all vertical and horizontal construction joints; and height of lifts. No concreting shall be started until the Engineer has approved the detailed proposals. Construction joints shall be so located as not to impair the strength of the structure.
- B. Positions of construction joint and size of formwork panels shall be so co-ordinated that, where possible, the line of any construction joints coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, as uniform joint shall be formed with a pattern of approved dimension to give a straight and neat joint line. Concrete placed to form the face of a construction joint shall have all Latinate removed and the aggregate exposed prior to the placing of fresh concrete. Latinate shall wherever practicable be removed by spraying the concrete surface with water under pressure and brushing whilst it is still green or by the application of surface mortar retarder followed by washing and scrubbing with stiff broom. Where the Latinate cannot be removed whilst the concrete is still green the whole of the concrete surface forming part of the joint shall have the aggregate exposed by means of a proprietary power driven scabbling/bush hammer as approved by the Engineer. Powerful hammers shall not be used and hacking, chipping, chiselling, etc. shall not be permitted. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing and the surface to which fresh concrete is applied shall be clean and damp.

C. Joints shall be located as follows:

1. in the middle third of span in slabs, beams or girders,
2. walls (vertical) away from corners; spaced at maximum 5m; where the concrete wall is monolithic with the floor or footing, the pouring of the wall shall commence within 7 days of placing the floor slab or footing with which it corresponds. Successive lifts in walls shall be placed within 3 days. Circular walls of tanks with a sliding joint between floor and wall are not subject to the 5 m panel limits referred to above if a lift in the wall is concreted as a continuous ring. Concreting shall then be carried out continuously in both directions until the ring is complete,
3. walls (horizontal) are only allowed when wall is continuous with floor slab and shall be keyed on cast kicker 150 mm high or on top of wall meeting soffit of suspended members,
4. a minimum 20 mm above soffit of beams connecting or 15 mm above soffits of slabs for columns,
5. ground slabs bearing on ground shall be cast in panels designed by movement subject to 7.5 m panel limits. Where no movement joints are specified or where the distance between movement joints exceeds 7.5 m in any direction for ground slabs and exceeds 7.5 m in length for wall slabs (except as described above under walls) they shall be sub-divided by properly formed construction joints into panels of dimensions not exceeding 7.5 m. Panels shall be separately concreted and, except as detailed below, no panel shall be concreted until the concrete in adjacent panel is at least 14 days old. These requirement will generally be met by casting in alternate bays in a chequer board fashion. If long and short bays are proposed, the long bays shall be concreted first. It is desirable that reinforcing bars extending across in-fill bays are not continuous (i.e. a splice is provided within the in-fill bay). If the Contractor adopts the above or other approved method to accommodate shrinkage, the Engineer may agree to a reduction in the 14 day time, but in no case will the approved period be less than four days. The peripheral ring beam in the floor of a circular tank shall not be concreted in advance of its integral floor slab. The periods referred to above do not apply to successive lifts in walls. The proposed sequence of casting panels as called for in this subsection shall be submitted for the Engineer's approval before commencement of concreting.
6. Non-structural ground slabs shall be cast as ACI 302 and shall be aligned with column or grid lines where practicable.
 - a. isolation joints shall be diamond-shaped or circular separations around columns ensuring all edges of slabs are isolated from adjoining construction.
 - b. control joints shall be spaced at 4 to 7m centres in both directions and spacing is dependent upon the type of coarse aggregate in the concrete as follows unless reliable data indicate wider spacings are feasible:

siliceous gravel or slag	: 4m;
crushed limestone	: 5.5m;
crushed granite	: 7m.
 - c. panels formed by joints shall be approximately square and in no case shall be the length/width ratio exceed 1.5:1. They shall be formed by either: sawing a continuous straight line in the top of the slab; grooving fresh concrete with hand grooves; or placing strips of wood, metal or pre-

moulded joint material at joint locations. The top edges of strips shall be flush with concrete. Control joints shall extend $\frac{1}{5}$ to $\frac{1}{4}$ x slab thickness into the slab.

- D. Expansion joints: reinforcement or other embedded metal items bonded to the concrete (except dowels in floors bonded on only one side of joints) shall not extend continuously through any expansion joint. Joints shall not be sealed until adjacent concrete is at least 28 days old. Joint sealant shall be prepared and installed in accordance with Section 07920 and manufacturer's instructions.
- E. Waterstops shall be fixed at locations indicated on the Drawings and shall be installed to give a continuous diaphragm in each joint. Pre-moulded waterstop shall be in maximum possible lengths to minimise the number of end joints. Joints at ends and intersections shall be made in the manner most appropriate to the material used and according to manufacturer's recommendations. Joints shall fully develop effective watertightness, equal to that of the continuous waterstops material; permanently develop not less than 50 percent of the mechanical strength of the parent section; and permanently retain their flexibility. Waterstop shall be fixed to formwork or reinforcement in accordance with manufacturer's recommendations. It shall be fitted accurately to formwork to prevent seepage of grout when concreting and shall not be fixed with nails or ties through the web of waterstop. Damaged waterstops shall be repaired before concreting. Waterstop shall be protected whilst protruding from an incomplete joint.

3.10 Concrete Finishing

- A. Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, "spaded" or "bonded concrete" or such other special finish as may be particularly specified. Where the class of finish is not indicated on the Drawings the concrete shall be finished to Class U1.
 - 1. Class U1 finish shall be the first stage for Class U2 and U3 finishes and for a bonded concrete surface. It shall be a levelled and screeded, uniform plain or ridged finish, which (unless it is being converted to Class U2, U3 or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing. Surplus concrete shall be struck off immediately after compaction. Where a bonded concrete surface is specified, the Latinate shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green. A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the works. Where a broom finish is specified, the surface of the concrete shall first be levelled and screeded and then brushed in one direction with a stiff broom.
 - 2. Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface has hardened sufficiently. Concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.
 - 3. Class U3 finish shall be a hard smooth steel-trowel finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess Latinate from being worked into the surface. Surface shall be trowelled under firm pressure and left free from trowel marks. All surfaces, which are not to be covered with a further finish, will be U3 finish. All surfaces on which further finishing screeds or treatment are to be applied, will be U2 finish.

- B. Concrete work shall be constructed to an accuracy which shall permit the proper assembly of components and installations and shall be compatible with the finish. The accuracy of the work shall be within the tolerances stated on the Drawings or specified elsewhere. For further information regarding tolerances see BS 5606

3.11 Concrete Inspection

- A. Concrete work will be subject to detailed inspection and tests at the plant and in the field. The Contractor shall notify the Engineer one day in advance of concrete work for inspections and tests. Sampling of concrete taken from the job will be carried out under the direction of the Engineer. Tests carried out by the Contractor in his site testing laboratory shall be under the direction of the Engineer.
- B. Concrete shall be produced in accordance with BS 5328 and this requires that tests are made on the constituent materials in accordance with the relevant British Standard. Control tests are made on concrete to ensure compliance with the specified requirements.
- C. The Contractor shall establish a plan for sampling and testing to the approval of the Engineer. When tested, the concrete shall meet the appropriate requirements specified in BS 5328, i.e.:
 - 1. characteristic compressive strength,
 - 2. specified mix proportions,
 - 3. minimum or maximum cement content,
 - 4. maximum free-water/cement ratio,
 - 5. workability,
 - 6. air content of concrete,
 - 7. temperature of fresh concrete,
 - 8. density of fully compacted concrete.
- D. The rate of sampling and testing shall be as specified and/or as directed by the Engineer and the cost of sampling and testing shall be borne by the Contractor. The atmospheric conditions, temperature of concrete, concrete constituents, and the state of reinforcement steel and formwork shall be monitored continuously during concrete placement.
- E. The Contractor shall facilitate sampling procedures and provide labour and material as required. The Engineer shall be notified when reinforcing steel is in place in order to facilitate any inspection he deems necessary. The Contractor shall submit checking sheets before placing concrete. Concrete shall not be placed until these inspections have been completed and all deficiencies reported by the Engineer have been corrected to the Engineer's satisfaction.
- F. The Contractor shall supply all moulds required for tests as described below. Moulds of the same type and manufacture shall be used for making all test specimens. If field tests show excessive slumps or other violations of the specified requirements, the entire batch of concrete from which the sample in question was taken will be rejected. Rejected concrete shall be removed from the site at the Contractor's expense. The Engineer will inspect all concrete operations in the plant and in the field.
- G. If ready-mix concrete is used, each load of concrete arriving at the job shall be accompanied by a delivery ticket which shall be subject to checking by the Engineer at the plant and which shall contain the following information:
 - 1. type and strength of the mix of concrete being delivered,

2. exact time the cement and aggregate discharged into the delivery truck,
 3. the Engineer will reject the load if, upon reaching the job, the concrete cannot be placed within the time limits stated, or the type of concrete delivered is incorrect.
- H. The Contractor shall keep records of all specimens taken and tests made in a format approved by the Engineer. These records shall be signed by the Contractor and the Engineer.
- I. Final acceptance of the concrete works is based on twenty eight day testing on the work test cubes. The work is considered in compliance if the average of the three cubes equals, or exceeds, the minimum specified for the class of concrete being placed and if no cube strength falls below 85 percent of the specified works test strength. If the results of the twenty eight day testing is unsatisfactorily, the Contractor, in accordance with the instructions of the Engineer, shall conduct tests in the suspect parts of the structure.
- J. As and where directed by the Engineer, cylindrical core specimens of 150 mm nominal diameter shall be cut perpendicular to the face of the hardened concrete in the Works for the purpose of examination and testing. The procedure for drilling, examination, measurement and testing for compressive strength shall be in accordance with BS 1881: Part 120. Prior to preparation for testing, specimens shall be made available for examination by the Engineer. If the crushing strength of the specimen in accordance with BS 1881: Part 120 is less than the minimum crushing strength given in Table 3.3 or if, in the opinion of the Engineer, the concrete fails to meet the specified requirements in other respects, the concrete in that part of the Work of which it is a sample will be considered defective.

3.12 Defective Concrete

- A. Defective concrete shall be defined as one or more of the following:
1. not conforming to required levels, lines, details and elevations,
 2. defective in required concrete strengths,
 3. defective in appearance in ultimate exposed areas due to:
 - a. improper placement or preparation of formwork resulting in bowed formwork,
 - b. improper formwork joints,
 - c. honey combing,
 - d. surface cracks or damaged surfaces,
 - e. exposed reinforcement,
 - f. improperly placed snap on or cone ties,
 - g. unsatisfactory conditions for the performance of sandblasting work etc.
- B. Defective concrete work must be reported to the Engineer. No remedial work shall be performed without the prior agreement of the Engineer, with respect to timing, method of repair, and final acceptable standard and appearance of completed repair work. Defective concrete members shall be totally removed and replaced if a satisfactory appearance (accepting satisfactory strength requirements) cannot be achieved, even after the completion of remedial work and members with satisfactory strength requirements including any adjacent members so effected.
- C. The Engineer's decision shall be final in all aspects related to the correction of defective concrete.

End of Section 03300

Section 03400: Precast Concrete

Part 1 General

1.01. Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Structural Precast Concrete Work.

1.02 Quality Assurance

- A. This Specification Section shall govern all structural precast concrete work for the project except where more stringent or specialized requirements are indicated.
- B. All work shall be performed to secure for the project homogeneous concrete having the required strength, surface finish, materials, durability, and weathering resistance, without planes of weakness or other structural defects, and free of honeycombs, air pockets, voids, projections, offset of plane and other defacements of concrete.
- C. The Contractor shall be fully responsible for any defects or damage in the structure or building arising from faulty materials or workmanship and the costs of remedial measures in order to ensure that the completed work complies with the Contract Documents.
- D. No alterations or substitutions of the structural systems shown on the Drawings shall be permitted unless otherwise specified.
- E. The Contractor shall supervise and co-ordinate all phases of the structural precast concrete construction process and be responsible for the complete manufacturing process. All methods of manufacture and practices of handling raw materials and manufactured concrete shall be reviewed by the Engineer prior to execution of the structural precast concrete work.
- F. Only materials of known quality shall be incorporated in the work. All materials shall be properly selected, reviewed and approved by the Engineer before use, and maintained during shipment, storage and use. Construction systems and techniques shall be properly selected, reviewed and approved by the Engineer before use, and maintained throughout the complete structural precast concrete construction phase. Adequate spare equipment, parts, additional components and repair facilities shall be available for all tools and equipment.
- G. Regardless of approvals by the Engineer, the Contractor shall be responsible for all materials and methods of structural precast concrete work. If any work does not satisfy the Contract Documents the Contractor shall at no additional cost to the Employer implement removal, replacement or remedial work and revise procedures or materials to prevent recurrence of unacceptable work.

1.03 Qualifications

- A. Structural precast work shall be executed by an approved specialist Sub- Contractor.
- B. The Contractor may execute this work himself if he can satisfy the Engineer that he has sufficient experience and expertise in this field and can provide satisfactory evidence that his tradesmen and their supervisory personnel engaged in such work have

successful experience with work comparable to that shown and specified. Details of organized quality control and testing procedures shall also be provided.

1.04 Testing

- A. Concrete shall be tested as specified in Section 03300 and load tests shall be conducted in accordance with BS 8110 before erection and also after erection.
- B. The Engineer will evaluate the adequacy of the Contractor's quality control. In addition to the requirements hereinafter specified under Paragraph "MIX DESIGN", the Contractor shall:
 - 1. furnish labour required to facilitate testing,
 - 2. inform the Engineer with at least one day's advance notice when concrete is to be placed,
 - 3. provide storage facilities for concrete test cubes,
 - 4. provide material samples and access to materials as required for testing.
- C. The Contractor shall station a qualified technician at the batch plant during the entire time of batching, and shall continuously test, inspect, and report on the following:
 - 1. the batching equipment and procedures,
 - 2. the conformance of the materials (cement, aggregates, water and admixtures) to the approved materials,
 - 3. Correct dosage of admixtures as prescribed by the manufacturer are used,
 - 4. the proportioning of the concrete,
 - 5. mix transport equipment.
- D. Should the batching plant be located more than 500 m away from the site offices, the Contractor shall provide suitable transport, acceptable to the Engineer, for the sole use of the Engineer's staff.
- E. The Contractor shall station a qualified technician at the casting site to continuously test, inspect and report. The tests shall comprise, for each thirty cubic metres of each different concrete type or portion thereof cast per day, six strength tests as BS 1881; slump tests; and temperature tests. The Contractor shall check and verify conformance with Contract Documents and approved shop drawings. The Contractor shall check all openings and provisions for full co-ordination with all trades in the Contract as shown on approved shop drawings.
- F. The Contractor shall provide facilities and equipment for the conducting of all tests specified herein except for the strength test which should be carried out by an approved independent testing agency.
- G. All welding of steel supports, anchorages, connections and attachments will be visually inspected by the Engineer.

1.05 Quality Control

- A. The Contractor shall prepare and provide his quality control programme for structural precast concrete work with particular attention to details, pre-checking processes, procedures and close supervision. In order to assure that proper work is performed to prevent later corrective actions, the Contractor shall provide at least one experienced supervisor full time to provide quality control for structural precast concrete work. The assignment will not relieve the Contractor's other quality control personnel of their duties relative to the quality control of the structural requirements and surface finish of the structural precast concrete work.

- B. The Contractor shall provide suitable quality control personnel who will be versed in quality control of structural precast concrete work including:
1. materials evaluation,
 2. special mix design techniques,
 3. mix placement,
 4. vibrator selection and use,
 5. formwork details formwork protection,
 6. release agent use,
 7. reinforcing steel,
 8. detailing and installation,
 9. finishing equipment and techniques,
 10. corrective procedures and protection of completed work.
- C. The Contractor's quality control personnel shall be responsible for verifying all details necessary to produce the final structural design objectives. The Contractor's quality control personnel shall also verify the quality of the structural precast concrete work and guide the production of results which will be within acceptable physical tolerances

1.06 Pre-construction Meeting

- A. Within a reasonable time prior to commencement of structural precast concrete work, the Contractor shall schedule a pre-construction meeting at a mutually agreeable time with the Engineer and his designated Representatives to discuss design, materials, methods of work and forming systems for structural precast concrete work.
- B. Prior to this meeting, the Contractor shall submit to the Engineer all pertinent information including:
1. written procedural outlines,
 2. description of forming systems,
 3. brochures of proposed equipment
 4. sources of all materials,
 5. characteristics of all materials,
 6. the above information shall be received by the Engineer at least 30 days prior to the pre-construction meeting.
- C. During the pre-construction meeting the Contractor shall present an outline plan for all concrete work to be accomplished and indicating special procedures relative to the structural precast concrete work. The outline shall include:
1. reviews of sources of materials commentary on source,
 2. source variations during the course of the work,
 3. storage and use of materials,
 4. description of all equipment necessary for batching, mixing, conveying, placing, forming, reinforcing, compacting,
 5. finishing of structural precast concrete.

1.07 Submittals

- A. Copies of manufacturer's specifications and installation instructions for each item of proprietary material used, showing compliance with these Specifications.
- B. Copies of mix designs with support material, as required by Contract Documents.

C. Copies of manufacturer's certificates of mill tests of all cement and reinforcing steel.

D. Product Design Criteria and Calculations including loadings for design:

1. initial handling and erection stresses,
2. all dead and live loads as specified on the contract drawings or as required,
3. all other loads specified for member where they are applicable.

The Design calculations shall be performed by a Structural Engineer experienced in precast concrete design. Calculations for the design of any precast member shall be supported by a statement explaining the principle of design and type of analysis adopted and the influence of any member in achieving the overall stability of the structure should be considered. Any computer programmes used in the designs shall be fully described and details of input and print out shall be presented in a manner which can be readily understood. Programme manuals and any instruction to programme users shall be made available to the Engineer upon request. Where any such programmes cannot be demonstrated by the Contractor to have been fully checked or where the Engineer considers it necessary, the Contractor shall run such test examples as the Engineer may choose, in order to verify the completeness and accuracy of the programme. Design members exposed to the weather to provide for movement of components without damage, failure of joint seals, undue stress on fasteners or other detrimental effects, when subject to seasonal or cyclic day/night temperature ranges. Design system to accommodate construction tolerances, deflection of other building structural members and clearance of intended openings. Calculate structural properties of framing members in accordance with BS 5328 and BS 8110.

E. Shop Drawings

1. Layout plans and detailed fabrication and placement drawings for each structural precast element.
2. Shop drawings are to include the following information:
 - a. size, grade, profile and dimensions of all materials used,
 - b. connection and anchorage details,
 - c. lifting devices, locations and handling limitations,
 - d. steel reinforcement details,
 - e. all openings, sleeves, inserts and other provisions in full co-ordination with all trades in the Contract,
 - f. identification marks.

F. Detailed outline of sequence and methods of erection.

G. A record shall be kept for every piece of precast element produced showing the following:

1. type and number
2. date of pour
3. concrete test results
4. reference shop drawing number
5. type and duration of curing
6. date of delivery to site
7. date of fixing in position

H. Copies of all testing and Inspection Reports.

1.08 Delivery, Storage and Handling

- A. The structural precast elements shall be removed from the forms without damaging or over stressing and stored or placed for transportation on a stable bed that will not allow further distortion of the member. Stacked members shall be separated with suitable battens and bracing.
- B. Each member shall be marked with an identifying reference or piece mark, and the date of casting. All piece marks are to be correlated with test reports and plan layouts or erection drawings.
- C. The structural precast element shall be transported with sufficient battens, bracing, and supports so as not to over-stress by vibration or impact loadings.
- D. Structural precast units shall be transported, stored and handled in a manner to avoid undue strains, hair cracks, staining, or other damage.
- E. Units from casting site shall be delivered to the project site in accordance with schedule and proper setting sequence.
- F. Structural precast units shall be stored free of the ground and protected from wind or rain splashes. Units shall be covered and protected from dust, dirt or other staining materials.
- G. During fabrication, construction and after erection, the castings shall be protected to avoid possibility of any damage.

1.09 Design Loadings, Actions & Structural Members Selection

- A. Precast elements shall be designed to withstand all loading conditions against which strength and serviceability must be measured.
- B. Vertical loads shall include own weight of precast elements, floor covering and live loads indicated on the Drawings.
- C. Wind pressure shall be calculated in accordance with the provisions of BS CP3 chapter V, Part 2:1972 "Basic data for the design of buildings - Wind Loads" using basic wind speed of not less than 100 km/hr.
- D. Account must be taken of the loads and deformation caused by temperature and time dependent deformations. For such purpose 55°C temperature variation and 90 percent relative humidity should be considered for all members, except exterior elements and facade elements where 85oC shall be consider.
- E. Floor systems are assumed to function as rigid diaphragms with respect to in plane forces. Forces due to lateral loads should be considered to achieve this assumed condition when designing peripheral beams and continuity ties etc.
- F. Precast elements shall be designed in accordance with BS 8110. Design tensile stresses should not exceed the design flexure tensile stress of concrete.
- G. Nominal cover to steel including links must meet the durability requirement of severe condition of exposure and to meet requirements for two hour period of fire resistance.
- H. Total deflection of any precast element should be limited to 1/350 of the span of this element.
- I. Plans & designs for openings for building services shall be accommodated, where required or necessary.

1.10 Co-ordination

The Work of this Section shall be completely co-ordinated with the work of other sections and the Contractor shall verify dimensions and Work of other trades which adjoin or pass through materials of this Section before the installation of items herein.

Part 2 Products

2.01 Materials

- A. The products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality. Products equivalent to, or better, than those specified will be considered acceptable. The decision of acceptability will rest with the Engineer.
- B. All materials shall be provided in accordance with, and meet all applicable requirements of, Section 03300. All cement, aggregates and water shall be provided from single sources, sufficient to complete the entire structural precast concrete work to assure regularity of appearance and uniformity of colour.
- C. Reinforcing bars shall conform to BS 4449 high strength deformed bars with a minimum yield strength of 460 N/mm². Reinforcement shall be epoxy coated in accordance with ASTM A 775 M-91 B where shown on the Drawings.

2.02 Mix Design

The mix shall be designed to obtain the strength specified. The compressive strength of the structural precast concrete shall be 35 N/mm² characteristic cube strength minimum at 28 days and 30N/mm² at the time of transfer. The slump shall be 100 mm. Air entertainment shall be 5 percent minimum and 7 percent maximum.

2.03 Formwork

- A. The formwork shall be as required to constantly maintain dimensional and surface finish controls specified in BS 5975. Formed surfaces of the structural precast elements are to be at least as smooth, flat and joint free as 19 mm plywood formed finished.
- B. Forms shall be constructed of non-staining metal, fibre-glass reinforced polyester, or other approved material. Forms shall be fabricated and reinforced for close control of dimensions, shapes, profiles, curvatures, smooth and perfect edges, and corner finishes and details. Forms shall be sufficiently rigid so that precast units will meet the casting tolerances and shall be constructed tightly to prevent leakage of water or mortar. Form joints will not be permitted on faces exposed to view in the finished work.

2.04 Form Release Agent

- A. The agent shall be a quick drying, non-staining type and the manufacturer's supplied solvents shall be used for cleaning re-bars and embedded items.

2.05 Bearing Pads

- A. Bearing pads shall be elastomeric neoprene, conforming to Standard Specifications for Highway Bridges (Section 25) adopted by the American Association of State Highway Transportation Officials with maximum compressive stress of 70 kg/sq. cm; maximum shear stress of 7 kg/sq. cm; maximum shear deformation of one half thickness; and maximum compressive strain of 15 percent. Unfactored loads shall be used for design.

2.06 Grout

- A. Non-shrink grout shall be non-shrink, non-metallic grout as specified in Section 03600.
- B. Epoxy grout shall be "Expocrete GP" (Expandite Ltd); "Hypol Epoxy Grout" (HBM Polymer Products Ltd); "Sikadur 42" (Sika Ltd) or other equal and approved.

2.07 Embedded Steel

All embedded items shall be of stainless steel Grade 316L.

Part 3 Execution

3.01 Forming

- A. Forms and casting beds are to be firmly seated so as not to deflect or be displaced under concreting or tensioning loads. For member penetrations larger than 150 mm coring or field cutting is not permitted unless prearranged with and approved by the Engineer. Clean and coat forms with release agent prior to installation or reinforcing or embedments.
- B. Refer to Section 03100 for materials and other requirements of formwork.
- C. Permissible deviations of formed surfaces are not to exceed tolerances outlined in PCI Manual 116, summarized and /or modified as follows:
 - 1. length: +/- 5 mm.
 - 2. width: +/- 3 mm
 - 3. thickness: Stem +/- 3 mm; Flange +/- 2.0 mm.
 - 4. embedment or penetration location: +/- 0.2%
 - 5. straightness: +/- 3 mm. for 300 cm
 - 6. end squareness: +/- 3 mm.

3.02 Reinforcing Steel Placement

- A. Reinforcing steel shall be placed in accordance with properly executed placement drawings. Embedments, inserts and lifting devices are to be firmly anchored to resist misplacement during concreting. Maximum permissible deviation from detailed placement.
 - 1. in plane: +/- 1/200
 - 2. in position: +/- 6 mm

3.03 Concrete Placement and Finishing

- A. Concrete shall be batched, transported, deposited, consolidated and struck off to produce dense homogeneous concrete elements.
- B. Surface finishes shall be broomed perpendicular to axis with stiff brush just sufficient to remove the outer mortar skin and expose the larger aggregate without disturbing the aggregate when a topping is to be applied; hand trowelled if exposed and floated if concealed.
- C. Curing shall be effected to retain moisture to ensure complete hydration of the cement. Membrane forming curing compounds shall not be used on surfaces to which topping is

eventually to be bonded. Steam curing shall not be applied until concrete undergoes initial set (2 to 4 hours) and the heat gain in the enclosure shall be maximum 4°C per hour with a maximum heat in the enclosure of 65°C.

3.04 Surface Treatment and Repair

Minor cracks and spalls not affecting the structural integrity of the element can be patched with epoxy type bonding agents and patching compounds. Cracks and honeycomb, in anchorages, bearings or otherwise critical zones will be unacceptable unless repair can be effected and substantiating testing performed. Structural repairs shall not be undertaken without the Engineer's knowledge and approval.

3.05 Installation

- A. Erection responsibilities include the safe and proper placing, aligning, and levelling of the structural precast elements on the accepted bearing surfaces and affecting their proper securement.
- B. Before placement of structural precast elements all temporary supports shown or required to control alignment and deflection shall be provided. Temporary supports shall be retained until framing elements braced thereby have attained integral stability in accordance with the design.
- C. All temporary supports shown or required to control alignment, deflection and stress levels shall be installed in proper sequence and maintained. They shall be retained until framing elements braced thereby have attained integral stability in accordance with the design.
- D. Any mis-alignment affect of temperature, draw from welding, bolting or erection sequence or grouting shall be compensated and corrected.
- E. Erection tolerances shall be:
 - 1. variations from plumb : 6 mm in any 6m run; 12 mm total in any 12m or longer run.
 - 2. variation from level or elevation : 6 mm in any run; 12 mm in any 12m run; total 12 mm at any location.
 - 3. variation from position in plan: +/- 12 mm maximum at any location.
 - 4. offsets in alignment of adjacent : 1.5 mm in any 3m run; 6 mm maximum. members at any joint
- F. Welding shall be in accordance with AWS recommendations. No welding shall be carried out until all adjacent elements to be connected have been aligned, firmly seated and braced. The heat build-up shall be controlled by limiting voltage, electrode size, and rate. Spalled or heat damaged concrete around weldments is not acceptable.
- G. Joints, gaps and connections shall be completed by filling with grout as shown on the Drawings and as approved by the Engineer.

3.06 Field Cutting

Field cutting of holes may be done only with the Engineer's concurrence, and only with power saws or core drills. The maximum hole size is 150 mm diameter or as limited by member size or strand location. Cracks, spalls and sharp corners created by field cutting are to be ground, eased, and patched with epoxy type bonding and patching compounds.

End of Section 03400

Section 03600: Grout

Part 1 General

1.01 Description

Furnish all plant, labour, equipment appliances and materials and performing all operations in connection with pre-mixed and packaged non-shrinking grout and site mixed grout/concrete containing an expanding additive.

1.02 Quality Assurance

Complete samples of the premixed and site mixed work in an approved location and obtain Engineer's approval before proceeding. The additive manufacturer's representative shall be present to supervise control sample.

1.03 Submittals

- A. Samples of any proposed additives and of any proposed premixed grout shall be submitted and product data from the proposed suppliers shall be provided.
- B. Prior to commencing work details of methods and techniques proposed for the design and execution of the work shall be submitted.

1.04 Delivery, Storage and Handling

- A. Delivery of cement shall be as specified in Section 03300. Premixed grout and additives shall be delivered to site in manufacturer's unopened containers, the labels of which shall bear the date of manufacture. The shelf life shall not exceed one year. Storage of cement and aggregates shall be as specified in Section 03300. Premixed grout and additives shall be stored in accordance with manufacturer's recommendations.

Part 2 Products

2.01 Premixed Grout

- A. Non shrink grout shall be non-metallic, chloride free, epoxy grout formulated to comply with U.S. Corps of Engineers Specification CRD-C-621-81. When tested under conditions of ASTM-C827 it shall indicate non-decrease in volume change.
- B. Curing compound (for application to exposed surfaces of grout) shall conform to ASTM C-309.

2.02 Cement

Cement shall be Portland cement as specified in Section 03300.

2.03 Aggregates

- A. Aggregates shall be as specified in Section 03300 and selected to reduce bleeding to a minimum.
- B. Fine aggregate shall be washed dry sand. The use of beach sand is not permitted

- C. Coarse aggregates shall be rounded and evenly graded; 10 mm nominal size except where pumping is employed when 6 mm nominal size shall be used. The percentage passing No. 16 sieve shall not exceed 5 percent.
- D. Additives shall be to the approval of the Engineer.
- E. Water shall be as specified in Section 03300.

2.04 Mixes

- A. The mix proportions and workability for each type of grout shall be selected to produce the required performance. The minimum characteristic strength of the grout shall be at least equivalent to the requirements for Grade 35 concrete as specified in Section 03300.
- B. Grout for filling uncongested areas over 50 mm wide shall have mix proportions of 1:1.25:1.75 (cement/fine aggregate/coarse aggregate 10 mm nominal size) by weight and with a slump of 100 - 200 mm. Grout for filling narrow areas less than 50 mm wide shall have mix proportions of 1:2 (cement/fine aggregate) by weight and with the slump to be kept to a minimum to allow placing.
- C. Dry packing for areas over 75 mm wide shall have mix proportions of 1:1:2 (cement/fine aggregate/coarse aggregate 10 mm nominal size) by weight and the slump shall not exceed 5 mm. Dry packing for areas less than 75 mm wide shall have mix proportions of 1:2 (cement/fine aggregate) by weight and the slump shall not exceed 5 mm.
- D. Alternative mixes incorporating additives shall only be used with the Engineer's prior approval.
- E. Premixed grout shall only be used to voids of small widths and apertures of limited accessibility.

Part 3 Execution

3.01 Mixing of Grout

Grout shall normally be mixed in a batcher mixer of a type approved by the Engineer and shall not be mixed by hand unless specifically approved by the Engineer.

3.02 Preparation of Foundation Surfaces

Surfaces of structural concrete foundation shall be thoroughly scabbled to remove all laitance to provide a clean rough surface. Bolt pockets and surfaces of concrete foundations shall be cleaned immediately before base plates are placed in position. Immediately before grouting, the spaces between the concrete and base plates shall be cleaned and thoroughly wetted. All excess water shall be blown away by means of a compressed air jet.

3.03 Transporting and Placing of Grout

Grout shall be transported from the mixer to the placing point quickly and in such a way that the materials do not segregate. Grout shall be placed within 45 minutes of being mixed. Grout shall be worked into position with chains, bolts, rods or other suitable instruments until the whole of the space is completely filled with the grout. Mechanical vibrators shall not be used. The main grouting and the grouting of bolt sleeves and pockets shall normally be carried out at the same time. If separate operations are advisable, bolt sleeves and pockets shall be grouted up to approximately 50 mm of the level of the concrete foundation before the main grouting.

End of Section 03600

Section 03900: Testing of Water Retaining Structures

Part 1 General

1.01 Description

The Contractor shall test water tightness of structures that are required to be watertight.

1.02 Submittals

The Contractor shall record and submit to the Engineer within 24 hours the results of the watertightness tests carried out.

Part 2 Products

2.01 Water

All water used for testing shall be potable water.

Part 3 Execution

3.01 Cleaning

All water retaining structures shall, on completion, be carefully cleaned, to the complete satisfaction of the Engineer. The structure shall be cleaned of all debris and shall be brushed down on all internal faces with a stiff broom while still dry. All resulting debris shall be removed. All associated pipework shall be cleaned in accordance with the Specification requirements. The structure shall then be flooded with approximately 75 mm of clean water. The whole of the internal faces shall be carefully brushed down with stiff brooms using the water continuously until all faces are clean. The water shall then be drained off and walls and floors hosed and flushed with clean water until perfectly clean.

3.02 Testing

- A. Structures intended and designed to be water-retaining (including all tanks, wet wells, basins, reservoirs, channels, sumps, chambers, etc. and any other structures designated as water retaining by the Engineer) shall be tested for watertightness after completion, in accordance with the following method or as directed by the Engineer. The structure shall be filled with potable water in stages not exceeding one metre in 24 hours. The water level shall be held in stages for such time as the Engineer may require. Should any dampness or leakage occur at any stage, the water shall be drawn off and the defects remedied to the satisfaction of the Engineer. In the case of structures which are sub-divided into individual tanks, each individual tank shall be tested separately. In the case of underground or semi-underground structures, the testing is to take place before application of water proofing membrane, liner material or any perimeter drain, filter material or backfilling is placed against the walls. In the case of hopper-bottomed tanks, this shall be taken to mean that no material is placed against the vertical external walls of the tank, the sloping walls of the hopper bottoms of the tanks being assumed built direct against the excavation apart from the blinding

concrete. No placing of any material whatsoever against the walls shall take place until the Engineer has given his written approval and acceptance of the water retaining structures as watertight. Filling shall not take place earlier than 28 days after the casting of the final sections of the structure which will be stressed by the filling of the structure. Testing shall not be undertaken until the structure to be tested has been completed structurally including roof, if any and has been passed by the Engineer in writing as satisfactory in all respects other than water-tightness, especially in regard to the final finish of the work. Notwithstanding the satisfactory completion of the seven day test, any leakage, cracks, wet/damp patches and sweating visible on the outside faces of the structure shall be rectified from the water face by an injection system to the approval of the Engineer. Repairs making the outer face only watertight will not be accepted. The structure shall be re-tested until the watertightness is approved by the Engineer. Should the part of the structure under the test fail the above tests in any respect, the Contractor shall immediately take such steps as may be necessary to ascertain the nature and positions of any defects or leakages, empty the structure and remedy the defects in a manner approved by the Engineer, employing men or a firm who are specialists in this class of work. When the remedial work has been completed in the manner approved by the Engineer, the testing and, if necessary, rectifications shall be repeated until a satisfactory test is achieved. If necessary, in extreme cases of lack of water tightness, the Engineer may reject the structure or any member or section of a member of the structure, in accordance with the Conditions of Contract. All expenses involved in the satisfactory water-tightness testing of all the water retaining structures in the Works shall be included by the Contractor. Any costs, as above, incurred by the Contractor in remedial or replacement work necessary to achieve the satisfactory testing shall be entirely at the expense of the Contractor.

- B. After completion and cleaning of the structure and all associated pipework, if any, the Contractor shall fill the structure up to the top water level and leave for a stabilizing period of 21 days in order to allow for absorption and autogenous healing to take place. Water shall be added over this period to maintain the top or high water level. The Contractor shall ensure that all pipes and specials are available in ample time ahead of testing. Two sets of evaporation trays shall be provided along with two sets of rain gauges. Levels in the trays and structure shall be made and recorded by a hook gauge with vernier attachments. Before and during testing, flows in the structure underdrainage, if any, shall be monitored, measured and recorded. Each underdrain shall be numbered and observations reported by underdrain number to facilitate analysis of the data. All leaks shall be repaired within one month of their detection. On the twenty second day, two shallow watertight evaporation trays of area 0.4 sq. metres shall be filled with 75 mm of water and placed to float in the structure. The water level in the structure shall be recorded and the test commenced and carried out over the next seven days. Readings of water levels in the structure and trays shall be made and recorded every 24 hours over this period. If the water level in the tank falls or any other sign of leakage occurs by the end of the test period then the Contractor shall search and mark all areas of defect. The structure shall then be emptied and the defects made good as specified herein. After completion of remedial measures the structure shall be refilled and the test repeated. This process shall be repeated until the structure is watertight to the satisfaction of the Engineer. The fall of water level in the structure over the test period of seven days, minus the fall accounted for by evaporation and rainfall shall not exceed $\frac{1}{500}$ of the average water depth of the full structure or 10 mm whichever is less. The roofs of structures shall be tested for water tightness before laying of any roof

membrane. Roof and fittings shall be hosed down vigorously and this shall be repeated in such a way as to keep the roof wet for three successive days. Roof and fittings shall be deemed satisfactory for watertightness if no discernible leaks or damp patches show in the soffit. Roof covering shall be completed as soon as possible after testing.

3.03 Disposal of Water Used for Testing

The Contractor shall provide suitable means for disposal of water used for testing, such that no damage results to facilities, structures or property. These means shall be subject to the approval of the Engineer and local authorities. The Contractor shall be responsible for any damage caused by his filling, testing, flushing and waste disposal operations.

End of Section 03900

Section 04220 : Concrete Masonry

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations for concrete masonry walls.

1.02 Quality Assurance

- A Work shall to be carried out by persons skilled in laying concrete masonry units.
- B Requirements for fire-rated or lateral support conditions are to be regulated in compliance with local building codes and are not necessarily fully defined on the Drawings. Whenever a fire-rating is shown for a wall use masonry units in that wall complying with the requirements established by the local governing authorities.
- C Mixer drums are to be painted white on the outside and kept white. All equipment, used for mixing transporting and laying mortar, shall be kept cool. Recording thermometers shall be placed at each location of concrete masonry work during its construction.
- D Brands or sources of supply for masonry materials shall not be changed during the course of the work.

1.03 Mock-up

Prior to the installation of concrete masonry work the Contractor shall provide a sample wall mock-up for all types of masonry units. Each sample wall panel shall use materials, together with bond and joint tooling, shown or specified for final work and special features as directed for caulking and contiguous work. Each sample wall panel mock-up shall be built at the site, as directed, of full thickness and approximately 1 m high x 1.5 m long, unless otherwise shown, indicating the proposed range of colour, texture and workmanship to be expected in the completed work. The Engineer's acceptance of visual qualities of each sample panel shall be obtained before proceeding with the final work. Each sample panel mock-up shall be retained during the construction period as a standard for judging completed masonry work and it shall not be altered, moved or destroyed until work is completed.

1.04 Submittals

- A The manufacturer's printed literature indicating product specification and installation instructions for each product required by this Section shall be submitted.
- B Manufacturer's certification that the following comply with the requirements specified shall be submitted:
 - 1 Portland cement
 - 2 masonry cement
 - 3 hydrated lime

- 4 mortar aggregates
 - 5 concrete masonry units (all types specified)
 - 6 reinforcing bars, etc.
- C Three samples of each type, and size, of hollow and solid concrete blocks shall be provided. These will be reviewed for colour and/or texture only and compliance with all other requirements, is the exclusive responsibility of the Contractor.
- D Shop drawings shall be provided as follows:
 - 1 shop drawing indicating details of anchors, inserts, joints, connections to adjoining work or materials, including elevations indicating setting out and placement of all joints, openings, cut-outs, etc.
 - 2 shop drawings for fabrication, bending and placement of reinforcing bars for unit masonry work complying with ACI 315. "Manual of Standard Practice for Detailing Reinforced Concrete Structures" unless more stringent requirements are specified. Show bar schedules, diagrams of bent bars, stirrup spacing, lateral ties and other arrangements and assemblies as required for fabrication and placement of reinforcement for unit masonry work.

1.05 Pre-installation Co-ordination

- A Prior to the start of each major type of masonry work, a meeting shall be held at the site to review the installation procedures and co-ordination with other work. The meetings shall include Contractor, Engineer and major material manufacturers as well as others whose work must be co-ordinated with the masonry work.
- B The Contractor shall ensure co-ordination between masonry work and concrete work such that all inserts and flashing reglets required for the proper installation of masonry work are correctly pre-installed.
- C A pre-installation inspection shall examine all parts of the supporting structure and the conditions under which the masonry work is to be installed. The Engineer shall be notified, in writing, of any conditions detrimental to the proper and timely completion of the work and installation of masonry work shall not proceed until satisfactory conditions have been corrected in a manner acceptable to the Engineer.

1.06 Delivery, Storage and Handling

- A Concrete masonry materials, other than bulk materials, shall be delivered to site in manufacturer's unopened containers, bundles, pallets or other standard packaging devices, fully identified with name, type, grade, colour and size.
- B All concrete masonry material shall be protected during shipment, storage and construction against wetting and soilage or intermixture with earth or other types of materials. Outside storage of masonry units and reinforcement shall be on plank platforms, off the ground, in dry locations. All necessary precautions shall be taken to prevent all masonry items from chipping, cracking or other damage during transportation, unloading and storage on site. Damaged units shall not be installed.

- C Metal reinforcing or ties having loose rust or other coatings that will reduce or destroy bond shall not be used.

1.07 Protection

A In hot weather all necessary precautions shall be taken to keep mortar and blocks and other materials cool and in particular mortar shall not be mixed or units laid while shade temperature is above 40°C on a rising thermometer or above 43°C on a falling thermometer. The temperature of fresh mixed mortar shall not exceed 32°C and suitable measures shall be taken to ensure this. Masonry units shall not be laid with a film of water on their surfaces.

B When the ambient air temperature is more than 30°C in the shade and the relative humidity is less than 50 percent, the masonry shall be protected from direct exposure to the wind and sun for 48 hours after installation. When work is not in progress partially completed unit masonry walls shall be protected against weather by covering top of walls with strong, waterproof, non-staining membrane which shall extend, at least 600 mm, down both sides of walls and be anchored securely in place, ensuring that there is free air flow sufficient to prevent heat build-up.

C Newly laid work shall be protected from the harmful effects of sunshine, rain drying, wind, running and surface water and shocks. Any work that is damaged shall be taken down and re-built or the joints raked out and pointed as directed by the Engineer. Scaffold boards shall be turned back during heavy rain and at night in order to minimize the possibility of staining the work. All work shall be kept clean.

1.08 Co-ordination

The Work of this Section shall be completely co-ordinated with the work of other sections and dimensions and work of other trades, which adjoin materials of this Section, shall be verified before the installation of items herein.

Part 2 Products

2.01 Materials - Mortars

A Portland cement for mortar shall comply with ASTM C 150, Type I, or BS 12, ordinary, non-staining, without air entrainment, natural colour or white as required to produce the required colour of mortar or grout. The cement content in the concrete mix used for the manufacture of blocks shall be less than 200 kg/m³ of concrete.

B Hydrated lime shall comply with ASTM C 207, Type S or BS 890.

C Aggregates shall comply with ASTM C 144, or BS 1200. The coarse aggregate used shall be 10 mm nominal size for standard blocks. For joints less than 6 mm aggregate graded with 100 percent passing the No: 16 sieve (1.18 mm) shall be used. Deleterious salt contents in aggregate shall not exceed the following limits depending upon the cement type used in the concrete mix. White aggregates shall be natural white sand or ground white stone. Coloured aggregates shall be ground granite, marble or other stone as required to match Engineer's sample.

	% wt of aggregate	
	Fine	Coarse
Acid soluble chlorides (Cl) % Max.		
If Concrete made with SRPC	0.03	0.02
If Concrete made with OPC MSRPC cement	0.05	0.04
Acid soluble sulphates (SO ₃) % Max.	0.30	0.30

D The acceptable levels of equivalent acid soluble chlorides and sulphates as specified above for aggregates are indicative and subject to the over-riding limits for the mixes as given below:

	By weight of cement in the mix
Acid soluble chlorides (Cl) % Max.	
If concrete made with OPC / MSRPC	0.40
If concrete made with SRPC	0.12
Acid soluble sulphates (SO ₃) % Max.	3.7

E Water shall be clear and free of deleterious materials, salts etc. which would impair the work. The pH value shall be in the basic range of 7 to 9 and inorganic impurities shall not exceed the following limits:

	Limits m(g/l)
Chlorides as Cl	250
Sulphates as SO ₃	250
Alkali carbonate and bicarbonates	500
Total dissolved ions, including above	2500

F Water retaining/reducing admixtures shall conform to BS 5075 Part I or ASTM C 499 Type B, free from chlorides and compatible with the cement.

G Plasticisers shall conform to BS 4887, and be free from chlorides and compatible with the cement.

2.02 Mortar Mixes, Non Load-bearing Masonry

Concrete masonry mortar shall conform to ASTM C 270, except limited to the mix materials specified above and the following cement/lime ratios by volume; wherein sand (in damp condition) equals 2¹/₄ to 3 times the sum of the volumes of cement and lime:

- 1 type M: not more than 1/4 part lime per part Portland cement.
- 2 type S: not more than 1/2 part lime per part Portland cement.
- 3 type N: not more than 1 part lime per part Portland cement.

2.03 Concrete Masonry Units (Blocks)

A Blocks shall be provided as shown, complying with type classifications, weights, grades and curing requirements as hereinafter specified and the following general requirements:

- 1 blocks for external and load bearing walls shall be solid blocks

- 2 blocks for internal partition, non-load-bearing walls shall be lightweight hollow blocks
 - 3 solid blocks are to be provided and placed in position where fixings or supports are required
 - 4 blocks shall have a textured surface to provide a good mechanical key for rendering but low suction qualities to prevent premature drying out
 - 5 do not use blocks which have chips, cracks, voids, streaks, iron spots or other substances which might stain exposed finished surfaces
 - 6 obtain blocks from one manufacturer, cured by one process and of uniform texture and colour, for each type required, for each continuous area and visually related areas
 - 7 work sizes of all blocks shall be in accordance with BS 6073: Part 2
 - 8 provide special shapes wherever shown and wherever required to build corners, lintels, jambs, control joints and expansion joints, and for other uses where necessary to provide a complete installation in accordance with the highest standard of workmanship.
- B Non-load bearing solid hollow concrete blocks shall conform to BS 6073: Part 1 using machine-expanded slag and the following:
- 1 Shale aggregate complying with ASTM C 331
 - 2 Dry net concrete weight of not more than 1680 kg/m³
 - 3 Grade N or the equivalent grade of BS 6073: Parts 1 and 2
 - 4 Average Compressive Strength of ten blocks shall be more than 7.5 N/mm² with minimum individual strength not less than 7 N/mm² when tested in accordance with Appendix 'B' of BS 6073: Part 1
 - 5 Blocks of thickness 75 mm or greater shall be tested for compressive strength and of thickness less than 75 mm tested for transverse strength. The average transverse strength of five samples shall not be less than 0.65 N/mm² when tested in accordance with Appendix 'C' of BS 6073: Part 1
 - 6 Average drying shrinkage of four samples should not exceed 0.05 percent when tested in accordance with Appendix 'D' of BS 6073: Part 1
 - 7 Average absorption of 3 samples shall not exceed 15 percent of its dry weight when tested in accordance with ASTM C140
- C Blocks shall be cured by low-pressure steam at a pressure of 0.7 kg/cm². The curing temperature shall be raised uniformly, at not more than 0.56°C per minute, from 30°C to 66°C. The masonry units shall be cured for approximately 3½ hours from initial set period, and thereafter kept moist for a period of 7 days by means of a fine spray of water, and then allow to air dry for 14 days. An interval of not less than 3 hours shall be allowed between the forming of the units and the curing process, and blocks shall be cured in a moisture-controlled atmosphere at normal temperature and pressure. Moisture absorption shall be limited to 35 percent of saturation at time of delivery and until time of installation. Curing shall comply with ASTM Type I classification.
- D Concrete block shall be units with exposed faces of the manufacturer's standard colour and texture, unless otherwise shown or specified.

2.04 Metal Ties, Anchors and Joint Reinforcement

- A Horizontal joint reinforcing:
 - 1 truss type welded wire units of 3 m lengths with prefabricated corner and tee units
 - 2 fabricate from ASTM A 82 or BS 4482 cold drawn steel wire with deformed side rods
 - 3 plain 9 gauge (3.7 mm) truss rods, crimped if used in cavity wall construction
 - 4 provide width of between 37 and 50 mm less than wall thickness
 - a fabricate with 9 gauge (3.7 mm) side rods, unless otherwise shown
 - b provide units with a single pair of side rods, unless otherwise shown
 - c for use in interior partition walls, fabricate from mill galvanised wire
 - d for use in exterior walls, hot dip galvanise after fabrication, with 458 g/m² zinc coating to ASTM A 153, Class B-2 or BS 729, Table 1.

- B Steel reinforcing bars for vertical reinforcement shall comply with BS 4449, size as shown or specified herein, free from mill scale and excess or loose rust deposits. Two 12 mm diameter bars shall be provided in each block.

- C Concrete inserts shall be of unit-type inserts of the type and size shown, of cast iron or malleable iron, or fabricated from not less than 2.6 mm steel with 458 g/m² hot-dip zinc coating to ASTM A 153, Class B-2 or BS 729 Table 1 after fabrication.

- D Dovetail strap type shall comprise dovetail slots with 22 mm wide flat bar anchors formed from 1.5 mm galvanized steel, with 6 mm upturned end or 12 mm diameter hole located within 12 mm of end. The anchor shall extend to within 37 mm of face of masonry units. At the Contractor's option, 3.7 mm galvanized wire triangular tie-backs with metal tabs for insertion into dovetail slots may be provided in lieu of flat bar anchors.

- E Provide bolt, strap, bar and rod anchoring devices of the type and size shown, but fabricated from not less than 1.5 mm sheet metal or 9 mm diameter rod stock unless otherwise shown. Devices shall be fabricated from steel with mill galvanized or hot-dip zinc coating.

- F Lateral supports for wall heads shall comprise continuous 50 x 50 x 3 mm thick metal angle on both sides.

- G Blockwork shall be restrained at vertical abutments with concrete with stainless steel wall starters with integral ties for building in.

2.05 Miscellaneous Metals

- A Wall Control Joint Filler:
 - 1 provide compressible control joint filler of closed cell PVC, SBR or Neoprene, either solid or tube type, of proper dimension to serve as back-up for joint sealant at face of masonry
 - 2 do not use control joint filler at building expansion joints
 - 3 provide solid rubber "key section" in control joint filler (60 to 80 Shore A durometer hardness) designed to maintain lateral stability in masonry wall.

- B For wood nailers and similar items to be set into the masonry work and for masonry reglets and flashings see other relevant sections of these specifications
- C Materials and sealants shall meet the required fire rating specified in Section 07910.
- D Damp-proof course shall conform to BS 743.

Part 3 Execution

3.01 Inspection

The Contractor shall inspect existing surfaces and ensure that they are satisfactory for work to proceed as specified, and shall report unsatisfactory conditions to the Engineer. Work shall not proceed until rectified to the satisfaction of the Engineer.

3.02 Workmanship - General

- A Work shall comply with the manufacturer's printed instructions and recommendations for the installation of each type of masonry product, unless otherwise shown or specified.
- B Masonry construction shall be built to the full thickness shown, except for single 'Wythe' walls masonry walls which may be built to the actual thickness of the masonry units, using blocks of nominal thickness shown.
- C Chases and recesses shall be formed as shown, and as may be required, for the work of other trades. Hollow blocks shall not be chased nor horizontal or diagonal chases cut in load bearing work. Not less than 200 mm of masonry shall be provided between chase or recess and jamb of openings and between adjacent chases and recesses.
- D Openings for equipment shall be left as shown or required to be installed at later date. Masonry work shall be completed after equipment is in place using materials identical with those immediately adjacent to the opening.
- E Unfinished work for joining with new work shall be stepped back. Toothing will not be permitted. Before new work is started the exposed surfaces of set masonry shall be cleaned and units lightly wetted (if specified to be wetted). Loose blocks and mortar shall be removed prior to laying fresh masonry.
- F Motor driven saws designed to cut blocks with clean sharp corners shall be used to cut blocks as required to provide pattern shown and to fit adjoining work neatly. Full blocks shall be used without cutting wherever possible and the use of less than half size blocks shall be avoided at corners, jambs and wherever possible at other locations. Chipped or broken blocks shall not be used.
- G Concrete blocks shall not be built in until at least 28 days after manufacture and until they are fully cured.

3.03 Laying Masonry Walls and Partitions

- A Except as otherwise shown or specified Type S mortar shall be used for exterior masonry work, Type N mortar for interior masonry work and Type M mortar for special structural requirements where shown, and for grouting reinforcing steel in masonry lintels unless concrete is shown.
- B Running bond for all single-wythe masonry walls shall be used unless otherwise shown. In multiple-wythe walls, bond wythes together with header blocks wherever possible, unless otherwise shown. Where wythes cannot be masonry bonded, ties of the type and spacing shown, shall be used unless horizontal joint reinforcing provides the tie between wythes. Where type and spacing of wire ties is not shown provide either continuous or individual type ties, installed so that double wires will be spaced not more than 600 mm centres both horizontally and vertically.
- C Solid hollow blocks shall be laid with completely filled bed head and collar joints and butter ends with sufficient mortar to fill head joints and push into place. Head joints shall not be slush jointed. Walls shall be laid up plumb and true with courses level and accurately spaced and co-ordinated with other work. Variations from plumb, true or level of more than 1/800 in any direction are unacceptable. Bearing plates, masonry anchors, flashings, sleeves, door frames and other miscellaneous items shall be built into masonry as work progresses and hollow metal frames adjoining masonry work shall be filled solidly with mortar. Anchoring devices shall be provided of the type shown, or of standard type if none are shown. Masonry work shall be anchored to all abutting structural members and space anchors 600 mm centres at vertical and overhead support locations, and 600 mm centres both ways behind masonry veneer work, unless otherwise shown. Uniform joint widths shall be maintained except for minor variations to maintain bond alignment. Except for cavity wall construction no voids shall be left between blocks and slush and grout back joints against other work as blocks are pushed into place. Masonry walls which are concealed or to be covered with other materials shall be finished with flush joints, unless otherwise shown. Exposed wall joints shall be tooled slightly concave, unless otherwise shown. Horizontal joint reinforcement and vertical reinforcement shall be provided in all masonry walls, unless specifically noted or specified to be omitted. Horizontal reinforcement shall be spaced at 600 mm centres for interior walls and 400 mm centres for exterior walls unless otherwise shown or specified. Reinforcement shall be lapped a minimum of 150 mm at ends. Control and expansion joints shall not be bridged with reinforcement except at wall openings. Matching prefabricated "T" and "L" sections of reinforcement shall be used at corners and wall intersections to provide continuity. Reinforcement shall be centered in wall to provide a minimum mortar cover of 15 mm at side rods.
- D Damp-proof course shall be protected with 12 mm thick cement mortar mix 1:3, shall be continuous throughout and stepped down where floor level changes and shall be laid full width of the wall with laps at corners and intersections not less than 75 mm.
- E Control joints shall be installed in masonry walls where shown and mortar shall be raked out in preparation for application of sealant.

- F If control joint locations are not shown, place joints vertically, spaced at each structural column or joint between bays of the building, but in no case spaced more than 9 m. Place vertical joints at points of natural weakness in the masonry work, including at locations where masonry wall height changes by more than 20 percent, above expansion or control joints in the supporting structure and where end of masonry wall butts against supporting structure.
- G Continuous control joints, 10 mm wide, shall be formed across structures where shown with build-in 40 mm wide x 200 mm long galvanized mild steel flats minimum 1.6 mm thick at each alternate course. Vertical joints shall be filled with mortar, except where wall is a fire compartment wall, when it shall be filled as described in other relevant Section of the Specifications.
- H Fine grout shall be used for filling spaces less than 100 mm in both horizontal directions and coarse grout for filling spaces 100 mm or larger in both horizontal directions. At the Contractor's option, use either low-lift or high-lift grouting techniques subject to the following requirements:
- 1 place vertical reinforcing before grouting and either before, or after, laying blocks, as required by job conditions. Support vertical reinforcing at intervals shown. Where individual bars are placed after laying masonry, place wire loops extending into cells as masonry is laid and loosen before mortar sets. After insertion of reinforcing bar, pull loops and bar to proper position and tie free ends.
 - 2 prior to grouting, clean and inspect grout spaces and close cleanout holes. Remove dust, dirt, mortar droppings, loose pieces of masonry and other foreign materials from grout spaces. Clean reinforcing and adjust to proper position as required. Clean top surface of structural members supporting masonry to ensure bond. After final cleaning and inspection, close cleanout holes and brace closures as required to resist grout pressures.
 - 3 do not place grout until entire height of masonry to be grouted has attained sufficient strength to resist displacement of masonry units and breaking of mortar bond. Install shores and bracing, if required, before starting grouting operations.
 - 4 limit grout pours to sections which can be completed in one working day with not more than one hour interruption of pouring operation. Place pour in lifts which do not exceed 1.2 m. Allow not less than 30 minutes, and not more than one hour, between lifts of a given pour. Rod or vibrate each grout lift during pouring operation.
 - 5 when more than one pour is required to complete a given section of masonry, extend reinforcing beyond masonry as required for splicing. Pour grout to within 37 mm of top course of first pour. After grouted masonry is cured, lay masonry units and place reinforcing for second pour section before grouting. Repeat sequence if more pours are required.
 - 6 for low-lift grouting the vertical reinforcing shall be placed prior to laying of masonry, shall extend above elevation of maximum pour height as required to allow for splicing and shall be supported in position. The masonry shall be laid to a maximum pour height not exceeding 1.2 m. Grout shall be poured using container with spout or chute. Rod or vibrate grout during placing. Place grout continuously; does not interrupt pouring of grout for more than one hour. Terminate grout pours within 37 mm of top course of pour.

- 7 for high-lift grouting cleanout holes shall be provided in first course at all vertical cells which are to be filled with grout. Units with one face shell removed shall be used and temporary supports provided for units above, or use header units with concrete brick supports, or cut openings in one face shell. Masonry shall be constructed to full height of maximum grout pour specified, prior to placing grout. Grout pours shall be limited to heights recommended by the National Concrete Masonry Association (NCMA) for the type of blocks, reinforcing and grout used in the work, but in no case exceed 3 m height.

3.04 Lintels

- A Masonry lintels shall be used wherever shown, and wherever openings in the masonry of more than 300 mm are shown without structural steel or other supporting lintels. Unless otherwise shown one reinforcing bar shall be provided for each 100 mm thickness of wall, and bars of adequate size shall be used in relation to opening width. A minimum lintel bearing at each jamb of 100 mm shall be provided for openings which do not exceed 1.8 m width. Lintels shall be precast and shall be cured thoroughly before handling and installing. In walls of concrete masonry units specially formed U-shaped lintel units shall be provided, with reinforcing bars placed as shown and filled with Type M mortar or concrete grout.
- B Steel lintels may be used with the approval of the Engineer and the Contractor shall provide sizes as recommended by the manufacturer.

3.05 Laying Exterior Walls

In addition to requirements specified above the following shall apply to the installation of exterior masonry walls:

- 1 space horizontal joint reinforcing bars at 400 mm centres in exterior walls, unless otherwise shown.
- 2 install reglets and nailers for flashings and other related work where shown to be built into masonry work.
- 3 provide flashings in masonry work as shown and extend details to corners and intersections to provide complete waterproofing.
- 4 keep cavity clean of mortar droppings in cavity wall construction and strike mortar joints flush as the work progresses.
- 5 place wall ties in cavity work as the work proceeds and set with slope to outer wythe. Do not raise one wythe more than 1350 mm above the other where wire ties are used or 450 mm above the other where any other type of tie is used. Close cavities at openings and top.
- 6 provide ties 150 mm long for cavities up to 50 mm wide and 200 mm long for cavities 51 - 100 mm wide.
- 7 space ties in cavity as follows:

) Wythes of thickness (one or both	Cavity Width	Spacing of Ties	
	Horizontal (mm)	Vertical (mm)	(mm)
90 mm or more both Wythes	50-75	900	450
90 mm or more both Wythes	75-100	750	450
90 mm or more both Wythes	100-150	450	450

3.06 Repair, Pointing and Cleaning

- A Blocks which are chipped, broken stained or do not match adjoining units as intended, or are otherwise damaged shall be replaced and new blocks provided promptly to match adjoining blocks. Mortar or grout joints shall be pointed up to eliminate evidence of replacement.
- B During the completion of masonry installation and the tooling of joints, any voids or holes shall be enlarged and completely filled with mortar. All joints shall be pointed up at corners, openings and adjoining work to provide a uniform, neat appearance, properly prepared for the application of sealant compounds and other work to follow. The exposed masonry surfaces shall be cleaned as follows:
 - 1 all exposed work shall be cleaned without the use of acid. Cleaning shall not be done until mortar is thoroughly set and hard. Before wetting wall, remove large particles of mortar by means of wood scraper, chisel or wire brush.
 - 2 the wall shall be pre-soaked, saturating the masonry with clean water and flushing off all loose mortar and dirt. Using a stiff fibre brush only, the wall shall be scrubbed down with a solution of 0.25 l household detergent and 0.25 l of trisodium phosphate dissolved in 4 l of clean water. All cleaning solution, dirt and mortar crumbs shall be thoroughly washed off using clean pressurised water.
 - 3 If after this cleaning procedure is completed, the wall or portion of the wall is not clean, in the judgement of the Engineer, the Contractor shall clean with an acid solution by methods acceptable to the Engineer. If cleaned with an acid solution, all sashes, metal lintels and other material shall be thoroughly protected.
 - 4 Particular care shall be taken to prevent smearing mortar on surfaces of concrete masonry units. If mortar smearing occurs, it shall be removed while soft, when possible; if dry and hard, it shall be removed by rubbing with a small piece of concrete masonry. All mortar smears, drippings, etc., on exposed faces of concrete masonry units shall be removed.

End of Section 04220

Section 07100: Waterproofing and Damp-proofing

Part 1 General

1.01 Description

- A. Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with sheet membrane and fluid applied waterproofing and bituminous damp-proofing
- B. The principal work of this Section includes, but may not be limited to:
 - 1. application of waterproof membrane to all portions below ground and up to 300 mm above grade of tanks and structures and roofs, floors of wet rooms like toilets, kitchens and pantries etc.,
 - 2. application of waterproofing to floors, walls and soffits of water tanks and reservoirs (internal faces), walls of wet rooms, walls of planters, etc.,
 - 3. protective painting of concrete foundation and sunken courts in contact with soil.

1.02 Qualifications

- A. Waterproofing shall be executed by an approved specialist Sub-Contractor having a minimum of five years successful experience in the installation/application of the specified material. Only tradesmen experienced with the installation/application of the materials specified shall be employed.
- B. The manufacturer shall provide evidence indicating that the specified materials to be used have been successfully utilised on work of similar scope to that shown and specified for this Project. The waterproofing system examples cited shall have been completed and in use for a minimum two years without evidence of failure.

1.03 Submittals

- A. Product data shall include:
 - 1. manufacturer's specifications,
 - 2. installation instructions,
 - 3. other data to show compliance with the Contract Documents.
- B. Shop drawings shall be prepared by the waterproofing membrane manufacturer.
- C. Samples of each type of following materials shall be provided:
 - 1. self-adhesive waterproofing membrane sheets and protection boards: 300 mm square,
 - 2. bituminous mastic: half litre container,
 - 3. primer: half litre container,
 - 4. fluid applied waterproofing: 300 mm square, on plywood.
 - 5. Cementitious crystalline waterproofing material-half litre
- D. Guarantee stating that the waterproofing system installed will be waterproof and free from defects for a period of not less than ten years from date of substantial completion of the Works. In the event any leaks occur within the period stipulated, the Contractor shall, at the convenience of the Employer, effect all repairs and replacements necessary to remedy defects all to the complete satisfaction of the Engineer at no additional cost to the Employer.

1.04 Pre-installation co-ordination

After approval of all materials and prior to installation, a pre-waterproofing conference shall be held at job site. In attendance shall be representatives of Engineer, Contractor, sub-contractor and manufacturer. The parties shall review Drawings, Specifications and approved materials. They shall examine job site conditions, including inspection of structures, material labels and methods of storing materials; correct conflicts, if any, between approvals and specification requirements; confirm that all curbs and edges are provided and correctly installed; and review installation procedures, co-ordination of the work with other trades, scheduling and temperature requirements.

1.05 Final Inspection

Upon completion of the installation, an inspection shall be made by a representative of the material manufacturer in order to ascertain that the system has been properly installed. Should there be any deviation from this specification without the prior written consent of the material manufacturer, the manufacturer shall have the option of refusing the guarantee.

1.06 Delivery, Storage and Handling

- A. Products shall be delivered in their original, tightly sealed containers or unopened packages, all clearly labeled with the manufacturer's name, brand name, and number and batch number of the material where appropriate, type and class as applicable, and the date of manufacture and expiration (if any). Materials shall be delivered to site in ample time to avoid delay in job progress and at such times as to permit proper co-ordination of the various parts.
- B. Products shall be stored as directed in a neat and safe manner. The storage area shall be shaded, protected from rain and surface water, ventilated and maintained at a temperature between 10oC and 24oC, and shall be located away from all sources of excess heat, sparks or open flame. Containers of liquid material shall not be left open at any time in the storage area.
- C. Products shall be handled in a manner that will prevent breakage of containers and damage to products.
- D. Materials not conforming to these requirements will be rejected by the Engineer and shall be removed from the site by the applicator and replaced with approved materials, at no additional cost to the Employer.
- E. All safety precautions on product labels shall be observed. Containers shall not be welded, heated or drilled. All caps or bungs shall be replaced and empty containers disposed from site.

1.07 Environmental Conditions

Bituminous damp-proofing shall not be applied during inclement weather or when the air temperature is outside the range recommended by the manufacturer.

1.08 Protection

- A. Waterproofing system installations shall be protected from damage during the construction period so that it will be without any indication of abuse or damage at the

time of completion. Other work damaged during waterproofing operations shall be repaired. Materials shall be prevented from running into, and clogging, drains.

- B. Local ordinances and fire regulations shall be complied with in the installation of hazardous materials specified or required under this section. All necessary precautions shall be taken against fire and other hazards during delivery, storage and installation of flammable materials specified herein.

Part 2 Products

2.01 Materials

Products and manufacturers specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than those specified, will be considered acceptable but the decision of acceptability rests with the Engineer.

2.02 Waterproof Sheet Membrane

- A. Waterproofing membranes and associated materials shall be sourced and supplied by a single manufacturer with a minimum of ten years experience. The manufacturer shall operate a Quality System which is registered to ISO 9001.
- B. The waterproof membrane sheeting shall be impervious, cold applied flexible laminated sheet consisting of multi-layer, high-density, cross-laminated, polyethylene film with a backing of self-adhesive rubber bitumen compound, a combined thickness of 1.5mm and protected with silicone coated release paper. A special grade of compound formulated for hot and wet climates must be used. The total weight shall be not less than 1.6 kg/sqm gross. The membrane shall be supplied in roll form not less than 20 metres long, not less than one metre wide, wound on a rigid tube and shall, in all respects, comply with the requirements of British Code of Practice CP 102 and BS 8102.
- C. Performance and testing of characteristics shall be as follows:

<u>Property</u>	<u>Test Method</u>	<u>Typical Results</u>
Tensile strength at break - film	ASTM D638	Long 42 N/mm ² Trans 51 N/mm ²
Tensile strength at break - membrane	ASTM D638	Long 4.2 N/mm ² Trans 5.1 N/mm ²
Elongation at break - film	ASTM D638	Long 230%, Trans 180%
Elongation at break - compound	ASTM D638	Trans 1250%
Tear strength - film	ASTM D1004	Long 380 N/mm Trans 360 N/mm
Tear strength - membrane	ASTM D1004	Long 30 N Trans 30 N
Adhesion to primed concrete	ASTM D1000	2.0 N/mm
Adhesion to self	ASTM D1000	4.0 N/mm
Puncture resistance of membrane	ASTM E154	230 N 53 mm
Water absorption - after 24 hours	ASTM D570	0.13% by weight
Water absorption - after 35 days		1.0 % by weight
Environmental resistance	ASTM D543	Conforms
Water vapour transmission rate	ASTM E96	

at 25°C, 75 % RH		0.3 g/m ² /24 hours
at 35°C, 90 % RH		1.0 g/m ² /24 hours
Adhesive softening point	ASTM D36	110 °C

- D. Preformed asphalt board, composed of aggregate bonded in bitumen and encased between two layers of asphaltic felt shall be supplied as 3mm thick boards 1.829 metres x 0.914 metres (1.67 sq.m.) weighing approximately 6.5 kg. The boards shall be spot bonded into position with high quality solvent borne contact adhesive based on polychloroprene rubber specially formulated for hot climates to give a minimum coverage of 10 to 12 sq. metres per litre of spot bonded area.
- E. Prior to the application of the waterproof membrane to vertical and horizontal surfaces (except horizontal blinding), the concrete will be primed with one brush coat of compatible primer containing 50 percent aromatic hydrocarbon solvents and 50 percent bitumen solids to give an average coverage of approximately 10 to 12 sq. metres per litre, dependant on texture and porosity of concrete surface. The primer shall be compatible with the waterproofing membrane and recommended by waterproofing membrane manufacturer.
- F. Preformed triangular fillet shall be black triangular PVC extrusion with a wall thickness of 5mm, 40mm x 40mm coated on two faces adjacent to rounded corner with grey self-adhesive compound protected by silicone coated release paper. The angle fillet shall be provided between slabs and upstands.
- G. Bituminous mastic shall be cold applied gun grade rubber/bitumen mastic compound, for moulding into fillets, collars and tapes for sealing around pipes and irregularities.
- H. Where polyethylene sheeting is laid under slabs and floors it shall be turned up and jointed to the membrane as recommended by the specialist manufacturer.

2.03 Bituminous Damp-proofing

Rubber bitumen emulsion shall comply with BS 3416 Type I, Class A or B. It shall be a water bound emulsion with a minimum 60 percent total solids content by volume, comprising bitumen with fine particles of rubber. Not less than 10 percent or more than 20 percent 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 comply with CP 231 for application of paint.

2.04 Cementitious Crystalline Waterproofing

Applicable standards

1.ASTM

2.Army Corps of Engineers

3. NSF International (NSF)

Products shall meet the requirements of ASTM E329-95 performed by an independent laboratory.

2.05 Chemical Resistance

Testing shall be performed according to ASTM C-267-77 "Chemical Resistance of Mortars".

Treated Specimens immersed in following solutions for a minimum 84 days shall not exhibit detrimental effects after exposure.

Hydrochloric acid (3.5 pH)
Brake fluid
Transformer oil
Caustic soda
Ethylene glycol
toluene

2.06 Potable Water Approval

Testing shall be performed according to NSF Standard 61 and approval for use of waterproofing material on structures holding potable water shall be evidenced by NSF certification.

2.07 Permeability

- A. Testing shall be performed according to US Army Corps of Engineers CRD C48-73 "Permeability of Concrete"
- B. Coatings of the testing sample to have minimum thickness of 1 mm per coat with up to two coats .
- C. Testing samples after crystalline growth has occurred shall exhibit no measurable leakage.

2.08 Submittals

A. Product data

Product data including manufacturer's specifications, installation instructions and general recommendations for waterproofing applications shall be submitted. All necessary certifications and other data substantiating compliance with the requirement of the contract shall also be produced.

B. Test Reports

Complete test reports from approved independent testing laboratories certifying that waterproofing system conforms to performance characteristics and testing requirements

C. Manufacturer's Certification

Certificates signed by manufacturer' representative or local agent certifying that the materials supplied for installation comply in all respect with the requirement of this specification and the applicator is qualified and approved to install the materials in accordance with the manufacturer's product data

D. Field report

Report from manufacturer's representative confirming that the surfaces to which the waterproofing to be applied are in a condition suitable to receive same

2.09 Quality Assurance

A. Manufacturer's qualifications

Manufacturer shall be ISO 9001 registered and shall have no less than 10 years experience in manufacturing the cementitious crystalline waterproofing materials for the required work. Manufacturers that can not provide the performance test data specified herein will not be considered for work

B. Applicator

Applicator shall be experienced in the installation of cementitious crystalline waterproofing materials as demonstrated by previous successful installations.

C. Technical Consultation

The waterproofing manufacturer's representative shall provide technical consultation on waterproofing application

Part 3 Execution

3.01 Preparation

- A. All surfaces to which the waterproofing and damp proofing are to be applied shall be examined and application shall not proceed until unsatisfactory conditions have been corrected and approved by the Engineer. The installation of waterproofing shall be coordinated with adjacent work which shall be masked to prevent soil marks.
- B. The substrate shall be cleaned and prepared in accordance with the manufacturer's instructions. Concrete surfaces shall be ground and filled as required to meet tolerances specified by the manufacturer. Waterproofing shall be applied to substrate in accordance with the manufacturer's instructions.
- C. Waterproofing and damp proofing shall not proceed until all drains, piping, conduit, vents, ducts and other projections through the substrate have been installed.

3.02 Installation of Sheet Membrane Waterproofing

- A. Surfaces to which the waterproofing materials will be applied shall be surface dry, smooth and free of dirt, grease or oil and shall be free from holes, honeycombing and loose aggregate which prevent satisfactory application of waterproofing materials. All surfaces to be waterproofed shall meet the approval of the Engineer before application of waterproofing materials.
- B. Installation procedures shall be in accordance with the manufacturer's standards. The membrane sheet shall be installed with minimum 120 mm overlaps at edges and ends and shall be rolled down firmly and completely. If the work must be left partially complete, the exposed edges of outside strips of membrane shall be finished with a trowelled bead of mastic.
- C. The work shall not proceed to vertical surfaces when the outdoor temperature is less than 10oC or more than 35oC. If the outdoor temperature at the proposed time of application is not within the above limits, application must be delayed until the permissible temperature range prevails or another system must be submitted for approval complying with these Specifications.
- D. The Contractor shall coordinate the self-adhering waterproofing membrane work so that the placement of the protection board will follow the waterproofing membrane application by not more than five days.
- E. Over the cleaned concrete or concrete blockwork surface the primer shall be applied the manner and using quantities in accordance with the membrane manufacturer's printed

instructions. The primer shall be allowed to dry before proceeding, but re-primed if not covered with membrane within 36 hours. After the primer has dried, the self-adhering membrane shall be applied to the concrete without stretching, with the polyethylene face out and it shall be smoothed down with heavy hand pressure or a small roller. The edges and ends shall be lapped as specified. The inside and outside corners shall be doubled by using an initial strip of 300 mm width membrane, centered along the axis of the corner. The strip shall be covered by the regular application of self-adhering membrane and the exposed edges of the membrane shall have a trowelled bead of mastic over these edges. The membrane shall be applied in two layers and laps shall be staggered from one layer to the next. The membrane shall be covered with two layers of protection board to protect it from damage during construction. Prior to reinforcement being placed over blinding concrete, the membrane shall be covered with the protection board as above. The protection board shall terminate flush with the edges of the concrete base slab and edges shall be covered by overlapping with membrane material. Sidewall membrane shall extend down and out to the edge of the previously applied horizontal slab membrane. Where top of membrane terminates at a reglet, the membrane shall be extended therein and the reglet filled with rubberized mastic. Areas around piping and protrusions shall be provided with an additional layer of self-adhering membrane for a minimum of 300 mm in each direction. The membrane edges shall be coated and the gap between the membrane and protrusions filled with mastic.

- F. Within five days after membrane application, asphalt protection board shall be installed to vertical and horizontal membrane-on-concrete surfaces. The board shall be installed with polyethylene face out, in two layers and with butted edges and ends, adhered to the membrane by means of mastic or other approved compound. Joints in the second layer shall be staggered in relation to the joints in the first layer. The exposed edges and gaps between penetration and edges of the protection board shall be pointed up with mastic.
- G. Protection board on horizontal slabs shall terminate at the outer corner of the concrete structure above and sidewall protection board shall extend down and out to cover the horizontal slab membrane.
- H. Backfilling shall not commence until the installation has been approved by the Engineer.

3.03 Installation of Bituminous Damp-proofing

- A. Bituminous damp proofing shall be installed in accordance with the manufacturer's printed instructions except as hereinafter specified.
- B. No coating shall be applied until the Engineer has approved the preparatory work.
- C. Surfaces shall be primed in accordance with manufacturer's instructions. The priming coat shall be made up by mixing 0.23kg. 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 square metre. 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 square metres. The emulsion shall be applied by brush, squeegee or spraying strictly in accordance with the manufacturer's instructions and shall not be applied during, or when rain or dust storms are to be expected.
- D. Backfilling shall not commence until the second coat of emulsion is dry.

Installation of Cementitious crystalline waterproofing material

- A. Concrete surfaces to receive waterproofing treatment shall have an open capillary system to provide tooth and suction, and shall be free from scale, excess form oil, laitance and foreign matter. Horizontal surfaces shall have a rough wood float or broom finish. Where a smooth trowel finish is required on horizontal surfaces, crystalline waterproofing material shall be applied by dry shake method at time of concrete finishing in accordance with manufacturer's data
- B. Surfaces covered with excess form oil or other contaminants shall be washed, lightly sand blasted ,water blasted or acid etched depending on the condition of surface as necessary to provide a clean absorbent surface. Surfaces to be acid etched shall be saturated with water prior to application of acid.
- C. All defects shall be made good as per specifications before application of waterproofing materials
- D. Prior to application of waterproofing treatment concrete surface should be thoroughly saturated with clean water to ensure migration of crystalline chemicals into voids and capillary tracts of the concrete. All free surface water shall be removed before application
- E. Curing of waterproofing shall be ensured as specified by the Manufacturer.

3.04 Testing and Guarantee

- A. On completion of waterproofing installation, areas shall be tested against leaks. No area shall be water tested within 48 hours after application.
- B. Water testing shall include flooding of tanked areas and slabs, either by section or entirely, for a minimum period of 48 hours. Flooding shall include proper damming of areas as required.
- C. Any area where leaks occur shall be drained, thoroughly dried, repaired, and then re-tested till no leak occurs over the whole area/s of test.
- D. At completion of flood testing, removal of all dams and traces of water shall be done and arrangements made for disposing off the water etc. All costs for water, for filling and for disposal as many times as necessary, shall be borne by the Contractor.
Where shown on the Drawings installation of sandbeds or concrete applied over the waterproofing shall not start until such time as the membrane is leak free and has been accepted by the Engineer.
- E. All waterproofing works shall be guaranteed for a period of ten years beginning from the date the Engineer certifies the Works to be substantially complete.

3.05 Clean up

The Contractor shall remove all masking, protection, equipment, materials and debris from the work and storage areas and leave those areas in clean, undamaged and acceptable condition.

End of Section 07100

Section 08210 : Wood Doors

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Wood doors and frames.

1.02 Requirements of Regulatory Agencies

Comply with requirements of NFPA and applicable local codes and fabricate door assemblies to comply with the requirements of NFPA No. 80 "Fire Doors And Windows" and be tested and rated for single point hardware by UL or local authorities and as per ASTM E 152 or equivalent test method.

1.03 Quality Criteria

- A. Provide doors meeting or exceeding the minimum standards as set forth by the following organizations unless standards are modified or exceeded by this specification.
 - 1. Architectural Woodwork Institute (AWI), Fourth Edition Section 1300 and 1500.
 - 2. National Wood Window & Door Association (NWWDA) IS-I-87.
 - 3. Commercial Standard CS 171-58 Premium Grade.
 - 4. National Electrical Manufacturers Association (NEMA).
 - 5. National Fire Protection Association (NFPA).
- B. All doors shall be the product of the same manufacturer to ensure uniformity of quality and appearance throughout the project.
- C. Fire doors shall meet with the approval the local authorities.
- D. Any discrepancies between the architectural drawings, and the procedures and limitations as set forth by the testing agencies shall be brought to the Engineer's attention.
- E. Provide each labeled fire rated door with a label permanently attached to either the hinge stile or the top rail showing testing agency approval for classification scheduled.

1.04 Submittals

- A. Shop Drawings
 - 1. Schedules and elevations indicating door sizes, construction, swing, label, undercut and applicable hardware locations.
 - 2. Dimension and detail openings for glass lights, louvers and grills.
 - 3. Number all doors in accordance with a plan agreed with the Engineer.
- B. Samples. If doors are to be factory finished, manufacturer shall submit veneer samples of specified veneer with their standard finish colors at Engineer's request.

1.05 Coordination

- A. Contractor shall be responsible for coordination and obtaining all necessary information from hardware and metal frame manufacturers.
- B. Door manufacturer shall be responsible for coordinating all necessary information received by the Contractor from hardware and metal frame manufacturers in order that doors shall be properly prepared to receive hinges and hardware.

1.06 Delivery, Storage And Handling

- A. Doors shall be shipped palletized in stacks of no more than 30 doors per pallet and door edges shall be protected by heavy corner guards. Doors shall not be delivered to the building until weatherproof storage space is available. Doors shall be stored in a space having controlled temperature and humidity range between 30 and 60 percent. They shall be stacked flat and off the floor, supported to prevent warpage and protected from damage and direct exposure to sunlight. Other materials shall not be placed on top of stacked doors.
- B. Factory finished doors shall be individually wrapped in black plastic bags to protect the finish from damage by contact with other doors and exposure to ultra violet rays.
- C. Use all means necessary to protect doors from damage prior to, during and after installation.

1.07 Warranty

Provide a written warranty from the door manufacturer that provides for the replacing, as originally furnished from the factory, any door exhibiting defects in materials or workmanship, including: delamination in any degree; warp or twist of 6 mm or more; telegraphing of any part of core unit through face to cause surface variation of 0.25 mm or more in any 75 mm span; or any defect which may, in any way, impair or affect performance of the door for the purpose which it is intended. Replacement under this warranty shall include hanging, installation of hardware and finishing.

Part 2 Products

2.01 Materials And Components

- A. Cores
 - 1. Particleboard core shall conform to Type I density 450-480 kg/cu.m, Class 1, commercial standard #236-66.
 - 2. Mineral core shall be asbestos-free, noncombustible mineral composition with minimum 450 kg/cu.m density when tested in accordance with ASTM # C303-82 and with ten percent maximum absorption by weight with core in equilibrium at 90 percent relative humidity and 21°C.

B. Edge Banding Stiles

1. Particleboard core

- a. Unless otherwise specified, a 38 mm double banded laminated hardwood stile shall be edge glued to the core.
- b. Outer band shall be of material compatible with face veneer of door.
- c. No finger joints shall be allowed in the outer band.
- d. 25 mm minimum softwood stile shall be used for edge framed construction.

2. Mineral core

- a. Shall be manufacturer's standard for application of full mortise hinges and the required label.
- b. No salt impregnation allowed.

C. Edge Banding Stiles

1. Particleboard core

- a. 32 mm mill option hardwood when used with edge glued construction.
- b. 32 mm softwood shall be used for edge framed construction.

2. Mineral core. Shall be manufacturer's standard for application of the required label.

D. Doorskins for wood veneered doors shall consist of a minimum 3-ply construction (face veneer, crossband and back veneer). Components shall be laminated to form a doorskin having a minimum thickness of 3.2 mm.

- 1. Face veneers shall be of teak.
- 2. Quality shall be governed by the ANSI/NWWDA and AWI (Sec. 1300-S-2).
- 3. Minimum thickness prior to factory sanding shall be 0.6 mm.
- 4. Crossband shall be thoroughly dried hardwood, extending full width and height of door with grain at right angles to the face and back veneers.
- 5. Back veneer shall be mill option thoroughly dried hardwood extending full width and height of door with grain parallel to the face veneer.
- 6. When plastic laminate door construction is specified:
 - a. Unit shall consist of 3 plies (face, core, face).
 - b. Faces shall have minimum thickness of 1.25 mm thick high pressure decorative laminate.
 - c. Stile shall be mill option hardwood.

2.02 Lights

Provide openings where shown for lights. Glazing beads shall be of hardwood. Glass in openings in doors and in transoms and sidelights shall be 6mm Georgian Wired clear polished plate glass in accordance with Section 08800.

2.03 Prefitting and Prematching

- A. Prefit doors and panels in accordance with tolerance requirements of Commercial Standard CS 171 or NWMA Industry Standard I.S. 1, at the place of manufacture and provide standard bevel or radius to edges of doors as required by the installation.

- B. Machine doors and panels for hardware requiring cutting of the doors at the place of manufacture. Machining shall be in accordance with hardware templates.

2.04 Shop Applied Lacquer

Door faces, edges and cutouts shall have one coat shop applied lacquer as specified at the place of manufacture. Surfaces shall be clean and dry before applying lacquer. Apply lacquer uniformly without runs, sags or bare spots to a dry film thickness of 25 microns.

2.05 Hardware

Provide first quality stainless steel door hardware including locks, with master key system, handles and door closures, etc.

Part 3 Execution

3.01 Inspection

The Contractor shall examine the Substrates, adjoining construction and the conditions under which the Work is to be installed and shall not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 Installation

- A. Do not install doors until concrete, masonry, plaster, tile and other wet work is completed and dried in the areas to receive doors.
- B. Doors shall be conditioned to the average prevailing moisture (humidity) of the locality before hanging and shall not be subjected to abnormal heat, dryness, or humidity. Avoid sudden changes such as forced heat.
- C. Cutting, trimming, fitting and machining of prefinished doors will not be permitted.
- D. Install doors in required openings as shown and install flush panels with concealed fasteners.
- E. Apply hardware in accordance with hardware manufacturer's instructions. Adjust door installation to provide uniform clearance at head and jambs, and to contact stops uniformly. Remove and replace doors which are found to be warped, bowed or otherwise damaged and cannot be properly fitted in frames.
- F. Remove hardware before painting and refix after painting of doors is completed. Adjust and lubricate hardware for proper operation at completion.

3.03 Cleaning And Protection

Upon completion of installation of doors, clean all exposed surfaces as recommended by the manufacturer.

End of Section 08210

Section 08330 : Rolling Shutters

Part 1 General

1.01 Description

The work covered by this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Rolling Shutters.

1.02 Requirements of Regulatory Agencies

All work shall be in accordance with the requirements of the authorities having jurisdiction and all applicable codes, rules and regulations, and ordinances.

1.03 Qualifications

Rolling shutters shall be installed and in full operative condition by experienced workmen in the type of installation required.

1.04 Submittals

- A. Copies of manufacturer's specifications and installation instruction for each type of rolling shutter to show compliance with these Specifications.
- B. Samples of each curtain slat shall be provided. The Engineer's review of samples shall be for design only and the requirements are the exclusive responsibility of the Contractor.
- C. Shop Drawings:
 - 1. Detailed drawings of special components required for the proper installation including anchoring and supporting systems.
 - 2. Prepare details at 1:5 minimum scale as approved by the Engineer and show details of adjacent wall and ceiling finishes.
 - 3. Number all doors in accordance with a plan agreed with the Engineer.

1.05 Delivery, Storage And Handling

Deliver rolling shutters and accessories completely identified for installation procedure.

1.06 Electrical Wiring

Provide insulated wiring meeting local regulations and provide electric power to isolators situated near the motors and wire from the isolators to the motors, control buttons and switches. Provide motors and other devices which are compatible electrically with building system voltage.

Part 2 Products

2.01 Rolling Shutters

- A. All shutters shall be provided by a single manufacturer.
- B. Steel Shutters:

1. Fabricate interlocking flat slats from rolled open hearth 18 gauge (1.2 mm) steel.
2. Use malleable end locks and wind locks.
3. Hot dip galvanize steel curtain with a high grade pure zinc coating 0.38 kg/m² of flat metal complying with ASTM A 90 and ASTM A153 free from blisters and other imperfections.
4. Bonderize galvanised surfaces for paint adhesion.
5. Fabricate a bottom rail and guides of structural steel.

C. Features

1. Design curtain to safely withstand a wind loads of 735 N/mm² for internal shutters and 980 N/mm² for external shutters.
2. Provide shutters with end locks, wind locks and weather seals.
3. Provide each shutter with bottom bar of two angles back-to-back, weather seal and safety bar is attached.
4. Coil each shutter on steel pipe of size sufficient to carry shutter load with a deflection not to exceed 1:400 of opening width, evenly balanced by springs. All springs shall be anchored to the same tension rod and held in position by the same adjusting wheel accessible from the outside of housing.
5. Provide coil brackets of heavy cast iron or fabricated steel to house the ends of the coil. Fit ends of roller shaft into bracket hubs of sufficient thickness to provide ample bearing surface for roller shaft and curtain. Equip operator bracket hub and plug-in spring end of shaft with self-lubricating bronze bearings or permanently lubricated sealed ball bearings.
6. Fabricate coil hood from not less than 24 gauge (0.60mm) galvanised sheet metal, reinforced as required for length of run. Provide removable ceiling panel for access to mechanism and removal of roller.

D. One and a half (1 1/2) Hour 'B' Label, tested in accordance with ASTM E152 or equivalent test method.

Part 3 Execution

3.01 Inspection

The Contractor shall examine the Substrates, adjoining construction and the conditions under which the Work is to be installed and shall not proceed with the Work until unsatisfactory conditions have been corrected.

3.02 Installation

Install doors in accordance with manufacturer's instructions. Anchors and inserts for guides, brackets, motors, controls, switches, and other work shall be accurately located. Upon completion, doors shall be free from warp, twist, or distortion and shall be lubricated and adjusted to operate freely acceptable to the Engineer.

3.03 Cleaning and Protection

Following complete installation of each rolling shutter, clean surfaces, joints and bearings of unit in accordance with manufacturer's instructions and lubricate as recommended by manufacturer. Protect each rolling shutter during construction period from weathering, deterioration or damage from any source so that it will be without any indication of use or damage at the time of completion of the Works.

End of Section 08330

Section 08520 : Aluminium Doors, Windows and Screens

Part 1 General

1.01 Description

The work included in this section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with aluminium doors windows and screens.

1.02 Qualifications

- A. Provide aluminium doors, windows and screens manufactured by a firm specialising in their production.
- B. Installation shall be carried out by workmen experienced in the type of installation required.

1.03 Submittals

- A Copies of manufacturer's specifications and installations and other data to show compliance with these specifications.
- B Shop drawings of all components including full size sections of all typical members, dimensioned elevations, anchors and other accessories required. Show glass thickness, glazing details and anti-burglar aluminium grills screw-fixed to the framing or anti-burglary laminated glazing where shown on the drawings. Number all doors in accordance with a schedule agreed with the engineer.
- C Samples
 - 1. Set of samples for each type, finish and colour.
 - 2. Specified alloy on 300 mm lengths of extrusion, show the maximum range or variation in colour and shade.
 - 3. Approval shall be for colour, texture, and specular gloss only and compliance with all other requirements is the exclusive responsibility of the contractor.
 - 4. Sample corners of door and window units, with hardware, representative of fabrication techniques and workmanship of the final products.

1.04 Warranty

Submit a guarantee for a period of five years that the fluoropolymer resinous coating will not develop excessive fading or excessive non uniformity of colour or shade and will not crack, peel or corrode.

1.05 Delivery, Storage and Handling

Deliver all components to site completely identified. Before dispatch from the manufacturer's works all exposed surfaces shall be protected with a suitable low tack tape, or other means of protection recommended by the manufacturer. Adhesion

resistance to atmospheric conditions and elasticity of the tape shall be suited to the purpose intended. If during fixing or glazing any protection is removed, it must be replaced immediately afterwards.

Part 2 Products

2.01 General

- A Except as otherwise indicated, units shall comply with all applicable requirements including air infiltration tests, water resistance tests, and applicable load tests specified in ANSI/AAMA 302.9 classification "PA-3 HP 60" and shall be suitable for a design wind load of 1780 n/m².
- 1. Tested in accordance with DD4 1971 up to severe exposure for water and air filtration or ASTM E 283 and E 331 and a certification of testing shall be provided.
- 2. Test reports indicating compliance shall be submitted prior to approval.
- 3. Doors, windows and screen units shall meet or exceed the following values.
 - a. Air infiltration shall not exceed 0.046 l/sec/m of ventilator perimeter when subjected to a static pressure drop of 298 n/mm² (80 km/hr.).
 - b. No water leakage shall occur during 15 minute application of 204 litres/m² of window area under a static pressure of 298 n/mm² (80 km/hr).
 - c. Maximum deflection of any member shall not exceed 1/175 of its span when tested for performance under uniform loading in accordance with ASTM E 330. When the load is removed there shall be no evidence of permanent deformation or damage.
- 4. Permanent deformation, disengagement or breakage of frame members and weld or fastener damage or failure shall not occur under loading equal to 1.5 times the design load and pressure, positive or negative. Permanent deformation is defined as deflection without recovery exceeding length 1000.
- B. Anchorage disengagement or breakage shall not occur when installed unit is subjected to a force equal to 2.5 times the design load.
- C. Make provisions at sill to drain water and condensation to exterior face of the frames.

2.02 Materials

- A. Aluminium extrusions
 - 1. Shapes as shown and as required to fulfil performance requirements, but not less than 3 mm thick and not less than 150 mm wide, unless otherwise shown.
 - 2. Suitable alloy and proper temper for extruding and fabricating with adequate structural characteristics, and suitable controlled alloy and temper as recommended by aluminium manufacturer to provide required colour and colour matching.
- B. Aluminium sheets and plates
 - 1. Minimum 3 mm thick or as required to fulfil performance requirements.

2. Suitable alloy and proper temper for forming and fabricating with adequate structural characteristics and suitable for finishing as required.
- C Steel angles, plates, bars, rods and other steel accessories required to join or reinforce assembly of aluminium components. ASTM A36 and ASTM A283, galvanized or, if galvanising is not compatible with alloy or component parts, shop painted with zinc chromate primer after cutting to size.
- D Aluminium angles, plates, bars and other aluminium members required to join, or reinforce, assembly of aluminium components. Alloys recommended by manufacturer or fabricator to develop required strength of assembly.
- E Fasteners. Stainless steel type 300 series, selected to prevent galvanic action with the components fastened. Where exposed in finished surfaces, use oval-head countersunk Phillips heads with colour to match adjacent surfaces.
- F Weather stripping. Moulded PVC gaskets, moulded expanded neoprene gaskets or moulded neoprene gaskets, factory applied in an integral dovetail self-locking groove.
- G Bituminous paint. As specific in Section 09900.
- H Hardware
1. Provide manufacturer's standard hinges, supporting arms, door closures, pull and locking handles, locks (with master key system) and all other hardware required for the operation indicated.
 2. Hardware shall be fabricated of stainless steel complying with ASTM A167 and finished to match the component to which it is fixed.
- I Glass and glazing. As specified in Section 08800.

2.03 Aluminium Doors and Windows

- A General
1. Construct aluminium door, window and screen units to the sizes and dimensions shown on the drawings and as specified.
 2. Doors and openable parts of the window and screen units (ventilators) shall be complete with all necessary hardware including bolts.
- B Unit construction
1. Glazed doors, windows and screens:
 - a. Provide framed members, fabricated with mitred joints, structurally welded with reinforcing inserts to develop the full strength of the metal and maximum rigidity in the frame assembly.
 - b. Fabricate doors of thickness indicated on the drawings and of sections which shall allow replacement of glass from inside without disassembly of doorstile and rails.
 - c. Provide snap on extruded aluminium glazing stops with exterior stops anchored for non removal.

- d. Provide sound deadening filler material on inside of stiles and rails.
- e. Clearances for door shall be 2 mm at jambs and heads, 6 mm clearance above finish floor except for carpet and 15 mm for carpets.
- f. Mortice, reinforce, drill and tap doors to receive hardware in accordance with hardware schedule.
- g. Openable (not sliding) windows shall be "turn & tilt" type wherever shown on the drawings.
- 2. Ventilators:
 - a. Mitre cut all corners, weld throughout entire section profile and dress welds smooth on all exposed and contact surfaces.
 - b. Vent members shall be designed to overlap the frame members to provide an uninterrupted compression seal around the entire perimeter of the window members providing true pressure equalising and to allow frictionless operation during opening and closing.
- 3. Frames, mullions and transoms:
 - a. Mitred, sealed rigidly and permanently joined.
 - b. Frames to be in one piece of largest size possible.
 - c. Provide intermediate support members where shown on the drawings or as required.

2.04 Aluminium Finishes

- A General:
 - 1. Remove die markings prior to finishing operations.
 - 2. Where necessary to remove die markings from any part of the work, all members must be finished by the same process, whether or not die marking exists.
 - 3. Perform the work in addition to the finish specified.
 - 4. Scratches, abrasions, dents and similar defects are unacceptable.
- B Finish shall be a one component fluoropolymer 3 coat system, factory applied with a total dry thickness of. 40 microns conforming to/exceeding the requirements of aama 605 by an approved applicator.

2.05 Aluminium & Glass (External) Colours

- A Colour of the aluminium and outer glass shall be as specified in the particular specifications.
- B Contractor may select glass from an established manufacturer in North America, Western Europe or Japan, with the provision that both the manufacturer and the colour shall be approved by the engineer.
- C The engineer will require at least four mock-ups of different colours to be made in order to make a final selection of the colours.

2.06 Fabrication

- A Complete the welding, cutting, drilling and fitting of joints prior to finishing.
 - 1. Weld with electrodes and by methods recommended by the metal manufacturer in accordance with applicable recommendations of the AWS.

2. Use only methods which will avoid distortion or discoloration of exposed faces.
 3. Grind weld areas smooth before proceeding with other treatment.
- B Conceal all fastenings unless otherwise shown or specified.
- C Fit and assemble all work in the shop as far as practicable. Mark and disassemble units which are too large for shipment to project site. Retain units in sizes as large as possible for shipment and erection.
- D Carefully fit and match all work with continuity of line and design, using rigidly secured joints with hairline contact, mitred corners, unless otherwise shown.
- E Reinforce members and joints with steel or aluminium plates, bars, rods or angles for rigidity and strength as needed to fulfil performance requirements using concealed fasteners for jointing which cannot be welded.
- F Separate unlike metals or alloys with a heavy coating of bituminous paint or other suitable permanent separation as required in order to prevent galvanic action.

Part 3 Execution

3.01 Inspection

The contractor shall examine the substrates and adjoining construction and conditions under which the work is to be installed and shall not proceed with the work until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Installation

- A Verify dimensions of openings by field measurements so that aluminium doors, windows and screens will be accurately designed, fabricated and fitted to the structure.
- B Co-ordinate aluminium doors, windows and screens, with the work of other trades and provide items to be placed during the installation of other work. Check the location of such items and verify that they have been set accurately in relation to the final location of doors, windows and screens.
- C Erect the doors, windows and screens, in accordance with the manufacturer's written instructions and recommendations and employing only experienced erectors.
- D Erection tolerances shall be variation from plumb: 3 mm maximum and variation from level: 3 mm maximum.
- E Cut and trim component parts during erection only with the approval of the manufacturer or fabricator and in accordance with his recommendations.
1. Do not cut through reinforcing members.
 2. Restore finish completely to protect material and remove all evidence of cutting and trimming.

3. Remove and replace members where cutting and trimming have impaired strength or appearance.
- F Do not erect members which are observed to be warped, bowed, deformed or otherwise damaged or defaced to such extent as to impair strength or appearance. Remove and replace members damaged in the process of erection, as directed.
- G. Set units level, plumb, and true to line, with uniform joints.
1. Support on metal shims and secure in place by bolting to clip angles and similar supports anchored to supporting structure.
 2. Use only the types of equipment, ropes, wedges, spacers, shims and other items during erection which will not stain or mark the finish of units.
- H Paint concealed contact surfaces of dissimilar materials with a heavy coating of bituminous paint, or provide other separation as per manufacturer's recommendations.
- I Weld with electrodes and by methods recommended by manufacturer of material being welded, and in accordance with appropriate recommendations of the AWS.
1. Use only methods which will avoid distortion or discoloration of exposed faces.
 2. Grind exposed welds smooth, using only clean wheels and compounds which are free of iron or iron compounds.
 3. Restore finish of component parts after welding and grinding.
- J Solder and braze only to fill or seal joints (not to form structural joints), and in accordance with component part manufacturer's recommendations. Grind smooth and restore finish.
- K Paint clip angles and other ferrous metal parts which will be concealed, with zinc chromate paint.
- L Seal joints in concealed manner, unless exposed sealant is shown.
- M Adjust ventilators and hardware to provide a tight fit at contact points and at weather stripping. Lubricate hardware and other moving parts.

3.03 Protection and Cleaning

- A Carefully remove protective material and clean down aluminium doors, windows and screens. Cleaning and protective methods shall be carefully selected, applied and maintained so that finishes will not become uneven or otherwise impaired as a result of unequal exposure to light and weathering conditions.
- B Remove deleterious materials from surfaces of aluminium immediately.

End of Section 08520

Section 08710 : Finish Hardware

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Finish Hardware.

1.02 Requirement of Regulatory Agencies

Furnish hardware in accordance with NFPA Standard No. 80 for openings specified for a fire rated opening or to receive a UL label. In case of conflict between type of hardware specified and type required for fire protection, furnish type required by NFPA and UL. Furnish hardware of type listed by UL for usage with the types and sizes of fire doors and frames required. Unless otherwise shown or specified, arrange doors at fire rated openings to remain in the normally closed position by furnishing each unit with an automatic closing device. Furnish active latch bolts of UL approved throw that cannot be held in retracted position.

1.03 Hardware Schedule

Refer to the door schedule on the Drawings.

1.04 Detail Requirements

- A. Where the type of hardware specified is not adaptable to the finished size of members requiring hardware, submit an item having a similar operation and quality to the Engineer for review.
- B. Make finish hardware to template, with wood and/or machine screws as applicable to door and frame details. Furnish templates and schedules to door and frame manufacturers and other trades requiring same so that doors and frames can be cut, reinforced and prepared in the shop to receive hardware.
- C. No names, designs, or labels will be permitted on turn-pieces, operating trim of lock sets or latch sets, push bars, pull handles or plates.
- D. Where several manufacturers are specified for one type of hardware, use only the products of one manufacturer.

1.05 Submittals

- A. Copies of manufacturer's specifications, maintenance and keying manuals, and installation instructions (templates to suit each particular installation), for each item of finish hardware. Include photographs, catalogue cuts, marked templates and other data as may be required to show compliance with these Specifications.
- B. Samples:
 - 1. One sample of each typical item of exposed hardware.
 - 2. The Engineer's review of samples will be for design, pattern, and finish and colour only.

3. All other requirements are the exclusive responsibility of the Contractor.
4. After final review, deliver samples to job site for comparison with hardware delivered for installation.
5. Unblemished samples may be used in work.

C. Finish Hardware Schedule:

1. Copies of finish hardware schedule covering complete identification of all items required for the project.
2. Include manufacturer's names and identification of finishes.
3. Include a separate schedule of key and master key system with final submittal of schedule.
4. The Engineer's review of schedules shall neither be construed as a complete check nor shall relieve the Contractor of responsibility for errors, deviations or omissions from requirement to provide complete hardware for project.

D. Original of statement stating that the finish hardware work complies with these Specifications, and that the methods of installation were proper and adequate for the condition of installation and use. Statement of application shall be signed by the Contractor.

1.06 Delivery, Storage and Handling

A. Delivery:

1. Deliver hardware in manufacturer's original, unopened packages.
2. Package and label each item of hardware separately.
3. Tag each item in accordance with the final hardware schedule.
4. Each package shall contain appropriate fastenings, instructions and installation templates.
5. Protect all items from loss or damage in shipment.

Part 2 Products

2.01 Hardware Finishes

A. Produce finishes to exact match with Engineer's selected samples.

B. Reduce variance in hue in the colour of each finish, as much as possible, whether the base material is cast, forged or stamped, or when plating is applied over steel, brass or bronze.

C. Finishes of the same designation, which come from two or more sources, shall match when the items are viewed at arms length and approximately 600 mm apart.

D. Unless otherwise specified, match the finish of each item of hardware with the finish selected for lock sets and latches.

E. Type of finish for each item of hardware is indicated on the Drawings.

2.02 Fasteners

A. Provide concealed fastenings where-ever possible.

B. The use of self-tapping or sheet metal screws is prohibited except for the application of flush mounted push and kick plates.

1. Concealed Fasteners. Furnish hardware with items with appropriate type and length of screws or other fastenings suitable to ensure permanent anchorage.

2. Exposed Fasteners. Furnish hardware with counter sunk Philips oval head type screws where concealed fastening is not possible. The finish or colour of these screws is to match that of the hardware item being fastened.

2.03 Butt Hinges

A. Provide all hinges with machine or wood screws as required by door and frame construction. Where door jamb or trim projects to such an extent that the width of leaf specified will not allow the door to clear such frame or trim, furnish hinges with leaves of sufficient width to clear. Furnish template hinges in accordance with door and frame material required.

B. Sizes for 45 mm door thickness shall be 100 x 100 mm.

C. Quantities per door leaf:

	Height of Door	No. of Hinges
1.	1.50 m or less	2
2.	1.51 m to 2.25 m	3
3.	2.26 m to 3.00 m	4

D. Hinge Base Metals. Interior: Stainless Steel.

E. Butt Hinge Characteristics. The following apply throughout the work:

a. Ball Bearing. Bearings contained within, or flush, with barrels and minimum metal gauge 3.3 mm.

b. Plain Bearing. Five knuckle flush barrel and minimum metal gauge 3.3 mm.

c. Pins. All interior hinges are to have non-rising pins. All exterior hinges are to have non-removable pins (NRP).

d. Tips: Button.

e. Application. Full mortice.

2.04 Mortice Locks, Latches and Deadlocks

A. Furnish mortice type lock sets and latch sets as scheduled.

B. All lock sets, latch sets or deadlocks to be furnished complete with trim and 5-pin cylinders.

C. Provide strikes for each lock set, latch set or deadlock with lips of sufficient length to protect frames. Provide a minimum 21 mm throw on lock sets and latch sets for pairs of doors and a minimum 21 mm throw on deadlocks for pairs of doors.

2.05 Cylinders

Standard 5-pin cylinders keyed into building system to suit lock functions.

2.06 Narrow Stile Door Locks

Locks to be furnished less cylinders. Master keyed cylinder 5-pin to be supplied as specified for Mortice locks.

2.07 Panic Devices

A. Single Doors: Rim type for single door; UL-Listed for fire exits and cylinder outside or no outside operation.

B. Double doors: One rim type and one rim vertical type, UL-listed for fire exits.

C. Furnish panic devices where scheduled, subject to the following:

1. Keyed devices shall be furnished less cylinders. Cylinders shall be as herein before specified, keyed to building system.
2. Outside Trims and Pulls shall be as specified.

2.08 Overhead Surface Door Closers

A. Closer sizes shall be as recommended by the manufacturer unless larger sizes are scheduled. They shall be full rack and pinion and have independent closing speed and latch regulating valves with adjustable backcheck and furnished for 180 degree opening where partitions will permit.

B. Additional features shall include reversible (non-handed) application permitting regular or parallel arm placement to suit door and installation requirements.

C. Overhead surface door closers shall be provided to all doors.

2.09 Flush Bolts

To be furnished in pairs (top and bottom of door) with the top bolt in a length sufficient to locate the flush bolt operator no more than 1.8 m above the finished floor. Furnish standard strikes for top bolts and "Dust-Proof Strikes" for bottom bolts. Flush bolts for metal doors to comply with ANSI A115.4 and for wood doors to have min 10 mm rods with a throw of min. 15 mm.

2.10 Pull Handles

Pull Handles shall be 225 mm "D" Handles located directly opposite each other where handles are required each side of the door. Provide bolt through fixing employing counter sunk corrosion proofed bolts with cup washers and locking patches.

2.11 Push Plates

Push plates shall be 300 mm X 100 mm X 2 mm minimum metal thickness.

2.12 Emergency Exit Devices

Emergency Exit Devices shall comply with the performance and dimensional requirements of BS 5725 or DIN 7140 and be mortice type with latches and vertical bolts concealed with stainless steel exposed surfaces unless otherwise specified. Keyed emergency devices shall be master keyed together with other locks.

2.13 Kick Plates

Surface mounted, bevelled 3 sides, 1.25 mm minimum metal thickness and mounted with oval head Philips fasteners. Size 100 mm high x door width less 37 mm for single doors or door leaf less 19 mm for pairs.

2.14 Door Stoppers

Door stoppers shall be provided for all metal, wooden and aluminium doors and shall be floor mounted except in wet areas. Size shall be 47 mm diameter with a 38 mm projection and wall mounted projection to be at least 63 mm and provided with a 45 mm long 12 g screw.

2.15 Keying System - Keying Control

- A. Provide 3 change keys per cylinder.
- B. Great grand master key system shall cover all door types such as wood, metal, aluminium doors, etc. The system has to be designed by the hardware supplier for approval of the Engineer and the Employer.
- C. Cylinders have a minimum of 5 pins.
- D. Provide keys of nickel silver only.
- E. Provide 5 keys for each master key level.
- F. Doors with panic devices shall have key operation from both sides.
- G. Finish of cylinders shall be US 15 to match finish of the hardware finish.
- H. Provide temporary cylinders for use during construction only.
- I. Provide 10 construction keys during construction period.
- J. After completion of installation and prior to handing over to the Employer, the architectural hardware supplier shall organise the transfer from construction master key system to the approved master key system.
- K. Provide steel key cabinet with cabinet lock having capacity of 200 hooks.

L. On handing over each key shall be fitted to a coloured nylon key tag with clear labelling of cylinder/key marking. All individual keys shall be placed on the hooks inside the key cabinet except the master keys, which are to be handed over in a sealed envelope by the hardware supplier's AHC. Each key shall have its door number punched on it.

Part 3 Execution

3.01 Installation General

- A. Receive hardware for doors as shown and scheduled, and as specified in the applicable hardware Sections of these specifications. Store in a locked space to prevent loss.
- B. Install to doors as recommended by hardware manufacturer and as required. Fit locks and latch in their respective doors and remove before painting. Reinstall after painting of doors is completed. Upon completion, adjust and lubricate hardware for proper operation.
- C. Instruct Employer's personnel in the proper adjustment and maintenance of hardware.

3.02 Hardware Mounting Heights

- A. Following mounting heights shall apply unless otherwise shown or specified:
 - 1. Lock Sets and Latches:
 - a. 950 mm to centre of handle from floor.
 - 2. Butt Hinges:
 - a. 300 mm to centre of lowest hinge from floor.
 - b. 175 mm to centre of upper hinge from top of door.
 - c. Space other hinges equally between lower and upper hinges.
 - 3. Door Pulls:
 - a. 1120 mm from finished floor to centre of pull.
 - b. Centre line in 125 mm from edge of flush doors and centred on stile of narrow stile glass doors.
 - 4. Deadlocks:
 - a. Centre line of cylinder to align with centre line of cylinder for lock sets, unless indicated otherwise.
 - 5. Cross-Bar of Exit Device:
 - a. 950 mm from finished floor to centre of cross bar.
 - 6. Push Bar:
 - a. 1050 mm from finished floor to centre of push bar.
 - 7. Push Plate:
 - a. 1120 mm from finished floor to centre of plate through mounted to pulls.
 - 8. Flush Bolt Operating Mechanisms:
 - a. Top bolt: 1650 to 1800 mm above finished floor.
 - b. Bottom bolt: 250 to 300 mm above finished floor.

3.03 Final Adjustments and Checking

Hardware supplier shall assist the Contractor in adjusting and checking the installation of finish hardware.

1. Check, test and adjust moving parts to ensure free and smooth operation.
2. Furnish to the Employer the special tools required to adjust and maintain hardware.
3. After the building is completed and in use, adjust hardware to compensate for air movement and other conditions, so that all items will operate properly.
4. A factory representative of the lock and latch manufacturer shall examine all hardware furnished, with an Employer's Representative, 6 months after handing over to the Employer and shall adjust the hardware for proper operation.

End of Section 08710

Section 08800 : Glazing

Part 1 General

1.01 Description

The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with glazing.

1.02 Reference Standards

The work shall conform to the codes and standards of the following agencies:

1. Conform requirements of FS DD-G-451d for the applicable quality hereinafter specified for each type of glass, except that for heat absorbing glass.
2. Acceptable range of colour and/or defects (as defined by FS DD-G-451d) shall be determined by samples of such defects and/or colour range. Glass which does not fall within the accepted sample range shall be subject to rejection by the Engineer. In the event that such samples are not or cannot be provided, the Engineer will determine the acceptability of glass relative to colour and/or observable defects in each case.
3. Comply with recommendations and requirements of "FGMA Glazing Manual" published by the Flat Glass Marketing Association.
4. Comply with recommendations and requirements of the "Glazing Sealing Systems Manual" published by the Flat Glass Marketing Association, except that for heat absorbing glass and insulating glass. Comply with the manufacturer's recommendations when they are at variance with FGMA.
5. Comply with recommendations and requirements of "Installation Recommendations for Tinted Glass", Technical Service Report No. 104, latest edition published by Pittsburgh Plate Glass Company.

1.03 Submittals

A. Manufacturer's Data:

1. Statement from the glass manufacturer that he has reviewed glazing details including the use of sealants and gaskets and that each product to be furnished is recommended for the application shown.
2. Statement from the glass manufacturer that he has reviewed all glass thicknesses as specified and application of heat absorbing glass for the effects of partial or full shading under the expected service temperature ranges and that the resulting thermal stresses will not reduce the "Glass Statistical Factor" below 2.5.
3. Manufacturer's literature for glazing gaskets and each type of glazing sealant (refer to Section 07920).

B. Provide the manufacturer's certification or guarantee of performance of the following glass types supplied for the designed and specified performance required:

1. Insulating Glass Units.
2. High Performance Reflective - Tinted Glass.
3. Georgian Wired Glass.

4. Laminated Glass.
5. Tempered/toughened Glass.
6. Mirror Glass.
7. Glass Blocks.

C. Samples

1. Each type of glass, glazing sealants and gasket.
 - a. Provide 300 x 300 mm samples of each type of glass specified.
 - b. Provide colour range samples for heat absorbing glass if production run colour variations are expected.
 - c. Provide 300 x 300 mm samples of expected production run appearance defects (if any) of heat absorbing glass.
 - d. Provide 300 mm long samples of glazing gaskets.
 - e. Provide cured glazing sealant samples as specified in Section 07920.
2. Samples will be reviewed by the Engineer for colour and texture only and compliance with all other requirements is the exclusive responsibility of the Contractor.

1.04 Sample Installation

- A. Prepare sample installation as required to match specified work in all respects before proceeding with the work.
- B. Glaze sample in the presence of both glass and glazing materials manufacturers, not less than one week in advance of the scheduled glazing work.
- C. Before actual glazing work proceeds examine the sample in the presence of those present earlier and obtain the Engineer's approval to proceed.

1.05 Delivery, Storage and Handling

- A. Deliver glazing materials to project site in manufacturer's unopened containers, fully identified with trade name, colour, size, hardness, type, class and grade.
- B. Store glass in accordance with manufacturer's recommendations and protect from weather, staining, damage and loss. Provide cushions at edges to prevent impact damage and protect faces from scratches and abrasion.

1.06 Environmental Conditions

- A. Do not perform glazing operations when temperature is below 4°C, unless the manufacturer of the glazing materials specifically recommends application of his materials at lower temperatures.
- B. Consult the manufacturer and establish the minimum provisions required to ensure satisfactory work when work progress when temperature below 4°C.

- C. Record in writing to the manufacturer, with copy to the Engineer, the conditions under which glazing work was performed and the provisions made to ensure satisfactory work.

Part 2 Products

2.01 Clear Glass

- A. Float Glass. Type I, class 1, quality q3, transparent, flat, float glass of glazing quality 6, 8 or 12 mm thick
- B. Wired Glass. 6 mm. thick polished plate, glazing quality.

2.02 Heat Absorbing Glass - Tinted

Float Glass. Type I, class 2, style B, flat, float heat absorbing, 6 and 8mm thick. Light reducing quality with lower light transmission and colour as selected by the Engineer.

2.03 Insulating Glass

- A. Fabrication:
 - 1. Fabricate units at factory with sheets of glass hermetically sealed at all edges with a permanent elastomeric sealant and a protective metal edge strip of aluminium or stainless steel.
 - 2. Metal edge strip and the frame to permit screwing in of the security grill in ground floor windows.
 - 3. Glass quality shall be as specified for each type. The outer light shall be 8mm thick tempered reflective tinted; 0.54 shading outside coefficient; air gap shall be 12mm; and inner light: 6mm clear float glass
- B. Manufacturers of insulating glass units shall have been in the business of producing units of similar size and configuration for not less than ten years. The insulating glass units shall be guaranteed by the Contractor for a period of ten years from the date of Substantial Completion of the Works not to develop material obstruction of vision as a result of dust or film formation on the internal glass surfaces as a result of the failure of the hermetic seal. In addition provide the manufacturer's standard guarantee valid for ten years from date of shipment to the project site.

2.04 Tempered/Toughened Glass

- A. Glass for tempering/toughening
 - 1. Float. Type I, class 1, quality q3, reflective, flat, float glass of glazing quality.
 - 2. Heat Absorbing, Type I, class 2, style B, flat, float heat absorbing. Light reducing quality with lower light transmission and colour as selected by the Engineer.
- B. Sizes and Cutting:
 - 1. Prior to tempering/toughening or heat treating, cut glass to required sizes as determined by accurate measurement of openings to be glazed, making allowance for required edge clearances. Cut and process edges in accordance with glass manufacturer's recommendations. Do not cut or treat edges in the field.

C. Full Tempered/Toughened Glass:

Provide glass tempered/toughened to increase flexural strength 4-5 times its strength before treatment. Locate tong marks along an edge which will be concealed in the glazing system. Do not exceed maximum warpage in either face of each piece, in any direction, as listed in the latest printed literature of Eckelt, PPG Industries or Pilkington.

D. Heat-Strengthened Glass:

Strengthened by manufacturer's standard heat-treatment process, which increases the flexural strength to not less than 2 times the strength before treatment. Do not exceed maximum warpage in either face of each piece, in any direction; as listed in the latest printed literature of Eckelt PPG Industries or Pilkington.

2.05 Mirror Glass

- A. Type I, Class 1, quality q1, if less than 2.25 m² or quality q2, if more than 2.25 m².
- B. Provide silvering, copper backing and protective coating conforming to FS DD-M-411.
- C. Mirror glass shall be guaranteed by the Contractor for a period of five years from the date of Substantial Completion of the Works not to show evidence of silver spoilage. In addition provide the manufacturer's standard guarantee valid for a period of five years from date of shipment to the project site.

2.06 Glass Blocks

Glass block shall be proprietary make, square, of size 190 x 190 x 80 mm as manufactured by Vegla, W. Germany or by Solar White, USA or approved equal.

2.07 Glazing Sealants

Refer to Section 07920 for Specifications and manufacturers of the types of sealants suitable for glazing work.

2.08 Glazing Gaskets

Refer to Section 07910 for Specifications and manufacturers of the types of sealants suitable for glazing work.

2.09 Miscellaneous Glazing Materials

- A. Setting Blocks. Neoprene or silicone blocks of 70 to 90 Shore A durometer hardness, tested for compatibility with specified glazing sealant. Use silicone only for silicone glazing.
- B. Spacers. Neoprene or silicone blocks of 40 to 50 Shore A durometer hardness, adhesive backed on one face only, and tested for compatibility with specified glazing sealant. Use silicone only for silicone glazing.

- C. Mirror Mastic. An adhesive setting compound manufactured specially for setting mirrors to plywood backing.

2.10 Fabrication

Cutting:

1. Obtain sizes from shop drawings or by field measurement.
2. Cut glass to fit each opening with minimum edge clearances and bite on glass as recommended by glass manufacturer.
3. Do not nip glass edges.
4. Factory cut all glass.
5. Take field measurements of each opening, before glazing, to verify adequate bite on the glass and minimum edge clearance.
6. Openings which do not fall within the tolerances for which precut glass has been sized shall be glazed only with glass specially cut to fit such openings.

Part 3 Execution

3.01 Condition of Surfaces

The contractor shall examine substrates and adjoining construction, and conditions under which work is to be installed and shall not proceed with work until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 Preparation

- A. A pre-installation meeting shall be held at the Site with the glass manufacturer's representative, sealant manufacturer's representative, glazier and fabricator of framing or other supporting structure to receive glass to review the glazing procedure applying glazing materials and installing removable stops; evaluate suitability of specified compounds and sealants for anticipated weather conditions and review co-ordination with other work.
- B. Before beginning work, inspect sash, frames and rebates to receive glass to determine that other trades have completed preparatory work and that sash and frames are ready to receive glazing materials.
- C. Sash, frames and members shall be adjusted, plumbed, and squared. All rivets, screws, bolts, nail heads, welds, and other projections shall be finished flush in glazing rebates. All corners and intersections shall be sealed and watertight.
- D. Operable sash shall be fastened and kept stationary until glazing compounds, except non-setting types, have cured or set.
- E. Surfaces to receive glazing materials shall be free of dirt, dust, grease, oil, and other foreign materials, and shall be painted or sealed before glazing work is begun.

3.03 Installation, General

- A. Installation of each light of glass shall be watertight and airtight, and capable of withstanding temperature changes, wind loading (exterior glass) and impact from operation (doors and operable sash), without failure of any kind including loss or breakage of glass, failure of seal, exudation of sealant and excessive deterioration of glazing materials.
- B. Inspect each piece of glass immediately before installation. Do not install any pieces which have damaged edges, scratches or abrasion or any other evidence of damage. Remove labels from glass before installation.
- C. Do not begin glazing until all cleaning and repairing of concrete and masonry surfaces has been completed.
- D. Aluminium glazed frames requiring dry glazing method shall be glazed in accordance with manufacturers written specification which shall become a part of the work herein as though written out in full.
- E. Follow "Surround Preparation" instructions of FGMA Glazing Manual and also thoroughly clean glazing surfaces of glass and frame.
- F. Do not begin glass installation until rebates and glazing stops have been primed and are thoroughly dry. Do no glazing when ambient temperatures are less than 4°C.
- G. All glass shall be clean cut.
 - 1. Nipping to remove flares or to reduce oversize dimensions will not be permitted.
 - 2. Shop cut to fit openings allowing required clearance.
 - 3. Openings to receive glass shall be perfectly square.
 - 4. Any out of square shall be reported and corrected before glass is sized.
 - 5. Protect edges of glass from abrasion with ground or adjacent surfaces.
- H. Cut glass accurately to fit openings. Sizes of glass indicated on the Drawings are approximate only and the actual sizes required shall be determined by measuring the frames to receive the glass. Size glass to permit required clearance and bite around full perimeter of glass as set forth in the FGMA Manual.
- I. Apply glazing compounds and other materials in strict accordance with manufacturer's printed recommendations.
- J. Glass shall be set without springing and with proper clearances at all edges. Edge clearance and tolerance shall be in accordance with recommendations of FGMA Glazing Manual, latest edition.
- K. All edges of exposed glass shall be ground and polished to profiles indicated, except as specified for glass mullions and entrance glass doors.

3.04 Glazing Methods

A. Interior Channel Glazing Method:

1. Metal doors, pressed metal frames and other interior openings required to receive glass, apply back-bed of elastic glazing compound over full face of backstop, and install spacer shims at least two at each edge and not greater than 600 mm o.c. to maintain uniform 3 mm thickness of bedding.
2. Press glass into back bed of compound.
3. Seal around entire perimeter of glass with elastic glazing compound.
4. Apply and secure face stops over 3 mm spacer shims and fill the space between face stops and glass with elastic glazing compound.
5. Tool compound at both sides of glass even with sight line.
6. When glass size is more than 1250 mm -(width plus height), install setting blocks at quarter points and use pre-shimmed polybutylene tape against fixed rebate in lieu of the glazing compound.
7. Tape shall be set slightly below the sight line for tolerance when pressure is exerted against the glass. Where tape is used, it shall be even with sight line.

B. Exterior Tape/Liquid Polymer Sealant Method:

1. At all areas where glass is set into frames, apply 3 mm minimum thickness pre-shimmed glazing tape over full face of backstop, using polybutylene tape and maintain precise edge at sight line except for sill which shall be kept back to receive final application of sealant.
2. Do not break tape except at corners and seal together with longitudinal pressure.
3. Set glass on neoprene setting blocks at quarter points allowing required clearance around full perimeter of glass.
4. Allow no direct contact between glass and frame.
5. Apply full heel bead of liquid polymer sealant around entire perimeter of glass.
6. Set 3 mm minimum thickness spacer shims on front face of glass as required to maintain uniform joint width, shove face stops into place, and secure.
7. Fill-in and finish with liquid polymer sealant. Interior shall receive sealant at full perimeter and exterior at sill only.
8. Trim tape at jambs and head even with sight line and tool all sealant to tight joint.

C. Exterior and Interior Dry Seal Glazing Method:

1. At all aluminium frames requiring gasket glazing set glass using setting blocks and applicable materials specified in accordance with manufacturer's written specification.
2. Replace all aluminium face stops in proper alignment with member securing in place without distortion and rattles.

3.05 Insulating Glass Glazing

Set insulating glass units as per manufacturer's recommendations to prevent water leakage. Do not glaze metal bound and organic bound insulating glass units with oil based mastic or other glazing compounds which might have a deleterious effect on the hermetic seal of the units. Completely conceal edge binding of insulating glass units with glazing material and extend material a minimum of 3 mm onto glass surfaces at each edge, to provide glazing seal independent of hermetic seal.

3.06 Structural Glazing Gaskets

- A. Comply with gasket manufacturer's printed instructions and recommendations.

1. Mitre-cut corners of loose zipper strips slightly longer to provide permanent compression at joints.
 2. Use special tool to install and remove filler strips.
 3. Lubricate as may be required, in accordance with manufacturer's instructions.
 4. Use lubricants recommended by gaskets manufacturer.
- B. Comply with glass manufacturer's printed instructions for the use of setting blocks, liquid or tape sealants and weep holes in the glazing recess of lock strip gaskets.

3.07 Field Quality Control

After completion of exterior glazing and nominal curing of sealants and glazing compounds, test for water leaks. Conduct tests in the presence of the engineer in accordance with "Specifications for Field Check of Metal Curtain Walls for Water Leakage", AAMA Standard FC-1-76, except perform tests on not less than 5 percent of all exterior lights.

3.08 Protection

- A. All glass shall be protected from damage until acceptance of the work and if glass is broken remove and replace with specified type. Contractor shall be responsible for protection of glass and the replacement of all such damaged materials after glazing work is completed.
- B. Glass breakage or damage to metal caused by negligence or any other reason shall be replaced at the expense of the Contractor.
- C. Contractor may, at his own option, carry glass breakage insurance, but failure to carry proper insurance shall in no way relieve him of his responsibility in this regard.
- D. All glazed openings shall be identified with markers such as tapes or flags that are not in contact with the glass, but which are held in position away from the glass.
- C. All glass shall be examined on a monthly basis during the guarantee period to detect any formation of staining and/or etching. If staining or etching is noticeable, notify Engineer immediately for determination of proper remedial procedures. Plaster, mortar, paint spatter, or any other coating shall be removed immediately after contact and shall not be permitted to collect or remain on glass surfaces.

3.09 Clean Up

- A. Remove all labels, excess glazing compounds, stains, and spots from glass and metal on completion of glazing.
- B. Remove all rubbish and debris from the site at the end of each day's work. Clean compound smears and stains from adjacent surfaces as the work progresses.
- C. At the completion of the work under this Section, all glass surfaces shall be thoroughly cleaned and washed. At the completion of the entire project all glass surfaces shall be thoroughly cleaned and washed.

End of Section 08800

Section 09870: Coating Systems for Ferrous Metals

Part 1 General

1.01 Description

- A. Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in Contract Documents and as specified herein. The work included in this section includes:
1. Coatings for all ferrous surfaces, interior and exterior.
 2. Submerged ferrous metal surfaces.
 3. Structural and miscellaneous steel, including tanks, hoppers, and similar equipment.
 4. Equipment furnished without factory finished surfaces.
 5. Exposed galvanized metal except handrails, grating, piping, and checkered plate.

1.02 Submittals

- A. Manufacturer's Data
1. Manufacturers current printed product description, materials safety, and technical data sheets for coating systems.
 2. Name and experience of manufacturer's recommended coating applicator, including list of installations painted, responsible officials and telephone numbers.
 3. Detailed mixing, thinning, and application instructions, minimum and maximum application temperature, and curing and drying times between coatings.
 4. Instructions for surface preparation requirements and number and types of coats required for each surface.
 5. Color charts for each coating system.
 6. Certifications from manufacturer verifying factory applied prime coatings are compatible with specified finish coatings.
 7. Detailed maintenance manual including the following information:
 - a. Product name and number.
 - b. Name, address and telephone number of manufacturer and local distributor.
 - c. Detailed procedures for routine maintenance and cleaning.
 - d. Detailed procedures for light repairs such as scratches and staining.
 8. Certified information for sandblasting abrasive, including:
 - a. Particle size distribution.
 - b. Dust generation at proposed operating pressure and distance and safety measures proposed for operatives.
 - c. pH value.
 - d. Soluble chloride content.
 - e. Analysis for free silica.
 - f. Trace toxic contaminants.
 - g. Safety measures proposed for applicators

- B. Sample Panels: apply a complete coating system to a panel of the same material as that on which the coating will be applied and submit for approval for each color specified. Approved sample panels will be used for quality control in applying coating systems.
- C. Certificates of Compliance.
- D. Inspection Reports.
- E. Test Reports.

1.03 Delivery, Storage and Handling

- A. Deliver materials in original, unopened packages and containers bearing manufacturer's name and label, including the following information:
 - 1. Name or title of material.
 - 2. Manufacturer's stock number and date of manufacture.
 - 3. Manufacturer's name.
 - 4. Contents by volume, for major pigment and vehicle constituents.
 - 5. Thinning instructions, where recommended.
 - 6. Application instructions.
 - 7. Color code and name.
- B. Storage
 - 1. Store materials near or on site in a suitable location, protected from exposure to extreme weather.
 - 2. Keep area clean and accessible.
 - 3. Restrict storage to coating materials and related equipment.
 - 4. Keep temperature of storage area between 18OC and 32OC.
 - 5. Comply with Local Laws and Regulations.
 - 6. Clothes and Cotton wastes that might constitute of fire hazard shall be placed in closed metal containers or destroyed at the end of each workday.
 - 7. Provide approved fire extinguishers in material storage area.

1.04 Quality Assurance Provisions

Submit name and experience record of manufacturer's recommended coating applicator including list of utility or industrial installations painted, responsible officials, architects, or engineers concerned with the project and the approximate contract price. Inspect surface and correct defects prior to application of each coat.

1.05 Environmental Conditions

- A. Unless otherwise recommended by coating manufacturer, the ambient temperature shall be between 7oC and 35oC when applying coatings other than water-thinned and epoxy.
- B. Water-thinned coatings shall be applied only when ambient temperature is between 10oC and 32oC.
- C. Epoxy coatings will be applied only within the minimum and maximum temperatures recommended by the coating manufacturer.
- D. Coatings, except water-thinned types, shall be applied only to surfaces that are completely free of moisture as determined by sight or touch.
- E. Do not apply to surfaces which have visible frost or ice.

Part 2 Products

2.01 Manufacturers

- A. No substitutions shall be considered that decrease film thickness, number of coats, surface preparation, performance criteria or the generic type of coating specified.
- B. Furnish coatings and coating products under this Section from a single manufacturer unless otherwise specified.

2.02 General

- A. Compatible materials shall be used as primer and finish coats of systems. Compatible barrier coats may be used between factory applied prime coats, or finish on existing surfaces to be refinished, and subsequent field coats with the Engineer's approval.
- B. Colors shall be as scheduled or selected by the Engineer, except prime and intermediate coats shall be tinted as approved by the Engineer to facilitate inspection of coverage for each coat.
- C. All products submitted shall conform to federal, state, and local requirements limiting the emission of volatile organic compounds.

2.03 Hazardous Materials Restrictions

Paints and painting practices shall comply with all applicable state and local laws enacted to ensure compliance with Federal Clean Air Standards.

2.04 Materials

- A. VOC:
 - 1. Maximum 0.33 kg/litre for shop applied primers.
 - 2. Maximum 0.42/liter for field applied coatings.
- B. Abrasive
 - 1. Chose particle size, shape, and specific gravity to produce desired surface profile for coating adhesion recommended by coating manufacturer. If not listed in manufacturer's literature, provide for a 50 to 75 microns average profile.
 - 2. pH value: Not less than 4 nor greater than 10 when mixed in neutral water.
 - 3. Soluble Chloride: none.
 - 4. Free Silica: meet government regulations.
 - 5. Trace Toxic Contaminants: to meet government regulations.
- C. Universal primer:
 - 1. Percent Solids: minimum 55 + 2 percent
 - 2. Abrasion: maximum loss per ASTM D 4060; 150 mg loss after 1000 cycles of CS-17 wheel.
 - 3. Hardness: minimum per ASTM D 3363; 3H.
- D. Epoxy-polyamide finish
 - 1. Percent Solids: minimum 55 + 2 percent
 - 2. Abrasion: maximum loss per ASTM D 4060; 150 mg loss after 1,000 cycles of CS-17 wheel.
 - 3. Hardness: minimum per ASTM D 3363; 3H.

- E. High-build acrylic polyurethane finish
 - 1. Percent Solids: minimum 68 + 3 percent.
 - 2. Abrasion: maximum loss per ASTM D 4060; 125 mg loss after 1000 cycles of CS-17 wheel.
 - 3. Hardness: minimum per ASTM D 3363; 2H
- F. High-build epoxy maintenance coating
 - 1. Percent Solids: 85 + 5 percent.
 - 2. Abrasion: maximum loss per ASTM D 4060; 130 mg loss after 1000 cycles of CS-17 wheel.
- G. Colors as selected by Engineer from manufacturer's standards.

Part 3 Execution

3.01 Workmanship

Paint and coatings shall be applied so as to produce an even film of specified thickness. Edges, corners, crevices, and joints shall receive special attention to ensure that they have been thoroughly cleaned and that they receive an adequate thickness of paint. Finished surfaces shall be free from runs, drips, ridges, waves, laps, brush marks, and variations in color, texture, and finish. Coverage shall be complete so that the addition of another coat of paint would not increase the coverage. Adjacent surfaces shall be protected by the use of drop cloths or other approved precautionary measures.

3.02 Items not to be Coated

Unless otherwise specified all ferrous metal surfaces shall be sandblasted and then coated. Hardware, hardware accessories, nameplate data tags, machined surfaces, and similar items not to be coated, but in contact with coated surfaces, shall be removed or masked prior to surface preparation and painting operations. Following completion of coating of each piece, removed items shall be reinstalled. Removal and installation shall be done by workmen skilled in the trades involved.

3.03 Preparation

- A. Surfaces to receive paint and protective coatings shall be cleaned as specified prior to application of coating materials.
- B. Examine surfaces to be finished, and correct surface defects before application of any coating material.
- C. Beginning the work of this section without reporting unsuitable conditions to the Engineer constitutes acceptance of conditions.
- D. Marred or abraded areas on shop primed and factory-finished surfaces shall receive touch up restoration prior to any other coating applications.

3.04 Sandblasting

- A. All sandblasting shall be done in strict accordance with the referenced specifications of the Steel Structures Painting Council, relevant sections of which have been reproduced hereinafter.

- B. When items to be shop primed or shop primed and finish coated in the shop, surface preparation shall be as specified in this Section.
- C. The Engineer shall have the right to witness, inspect, and reject any sandblasting done in the shop.
- D. When sandblasting is done in the field, care shall be taken to prevent damage to structures and equipment. Pumps, motors, and other equipment shall be shielded, covered, or otherwise protected to prevent the entrance of sand. No sandblasting may begin before the Engineer inspects and approves the protective measures.
- E. The following surface preparations for metal surfaces to be painted or given protective coatings shall form part of this Section:
 - 1. White Metal Blast Cleaning (For very corrosive atmosphere): removal of all visible rust, mill scale, paint and foreign matter by blast cleaning by wheel or nozzle (dry) using sand, grit or shot.
 - 2. Near-White Blast Cleaning (For high humidity, chemical atmosphere, marine or other corrosive environment): blast cleaning nearly to White Metal Cleanliness, until at least 95 percent of each element of surface area is free of all visible residues.
 - 3. Commercial Blast: blast cleaning until at least 67 percent of each element of surface area is free of all visible residues.
 - 4. Brush-Off Blast Cleaning: blast cleaning of all except tightly adhering residues of mill scale rust and coatings, exposing numerous evenly distributed flecks of underlying metal.
 - 5. Solvent Cleaning: removal of oil, grease, dirt, soil, salts and other contaminants by cleaning with solvent, vapor alkali, emulsion or steam.
- F. Surface preparations shall be done to the satisfaction of the Engineer. No painting or protective coating shall be applied before the Engineer has inspected and approved the preparation.
- G. After sandblasting, dust and spent sand shall be removed from the surfaces by brushing or vacuum cleaning.

3.05 Application of Protective Coatings

- A. Shop Coating
 - 1. Fabricated metalwork and equipment which requires coating may be shop primed with specified primer.
 - 2. Any such work delivered to the job site with any other shop coat shall have this coating removed and the specified coating applied in the field.
 - 3. Manufactured equipment with approved corrosion resistant factory finishes and galvanized finishes shall be exempt from this requirement of stripping
- B. Field Coatings
 - 1. Except where in conflict with the manufacturer's printed instructions, or where otherwise specified herein, use choice of brush, roller, air spray, or so called airless spray application.
 - a. Any spray painting must first have the approval of the Engineer.
 - b. Areas inaccessible to spray coating or rolling shall be coated by brushing or other suitable means.
 - 2. Give special attention to ensure that edges, corners, crevices, welds, bolts, and other areas, as determined by the Engineer, receive a film thickness at least equivalent to that of adjacent coated surfaces.

3. All protective coating materials shall be applied in strict accordance with the manufacturer's printed instructions.
4. Prime coat shall be applied to clean surfaces within a 4 hour period of the cleaning, and prior to deterioration or oxidation of the surface, and in accordance with the manufacturer's recommendations.
5. Coatings shall be applied in dry and dust free environment.:
6. No coating or paint shall be applied during following conditions:
 - a. When the surrounding air temperature, measured in the shade, is below 15oC.
 - b. To wet or damp surfaces.
 - c. In rain, fog or mist, or when the relative humidity exceeds 85%.
 - d. When it is expected that the relative humidity will exceed 85% or that the air temperature will drop below 5oC within 18 hours after the application of the coating or paint.
 - e. Dew or moisture condensation shall be anticipated.
7. If above conditions are prevalent, painting shall be delayed until surfaces are dry.
8. The day's coating shall be completed in advance of the probable time of day when condensation will occur in order to permit the film a sufficient drying time prior to the formation of moisture.
9. Care shall be exercised to avoid lapping or dripping paint on adjacent surfaces:
 - a. Coatings shall be sharply cut to lines.
 - b. Finished coated surfaces shall be free from defects or blemishes.
 - c. Drop cloths shall be used to protect floors, fixtures, and equipment.
 - d. Care shall be exercised to prevent paint from being spattered onto surfaces from which such paint cannot be removed.
 - e. Surfaces from which paint cannot be removed shall be painted or repainted as required to produce a finish satisfactory to the Engineer.
 - f. Whenever two coats of a dark colored paint are specified, the first coat shall contain sufficient powdered aluminum to act as an indicator of proper coverage, or the second coating shall be of a contrasting color.
10. Surfaces inaccessible after assembly shall be coated before erection:
 - a. No structural friction connections, high strength bolts, and nuts shall be painted before erection.
 - b. Areas damaged during erection shall be hand or power tool cleaned and recoated with prime coat.
11. Touch up of surfaces shall be performed after installation.
12. All surfaces to be coated shall be clean and dry at the time of application.

C. Time of Coating

1. Manufacturer's recommended recoat time shall be complied with.
 - a. Sufficient time shall be allowed to elapse between successive coats to permit satisfactory recoating, but, once commenced, the entire coating operation shall be completed without delay.
 - b. No additional coating of any structure, equipment, or other item designated to be painted shall be undertaken without specific permission of the Engineer until the previous coating has been completed for the entire structure, piece of equipment, or other item.
2. Piping shall not be finish coated until it has been pressure tested and approved.

- D. Thickness of Coating: dry film thickness specified shall be achieved and verified for each coat.

3.06 Testing and Inspection

A. Inspection Devices

1. The Contractor shall provide, until final acceptance of coating and painting, inspection devices in good working condition for detection of holidays and measurement of dry film thickness (DFT) of coatings and paints.
2. Furnish U.S. Department of Commerce, National Bureau of Standards certified thickness calibration plates to test accuracy of DFT gauge and certified instrumentation to test accuracy.
3. Dry film thickness gauges shall be made available for the Engineer's use until final acceptance of application.
4. Holiday detection devices shall be operated in the presence of the Engineer.
5. Inspection devices shall be operated in accordance with the manufacturer's instructions and when directed by the Engineer's representative.

B. Conduct DFT measurements and electrical inspection of the coated surfaces.

C. Recoat and repair as necessary for compliance with the specifications.

D. After repaired and recoated ferrous metals areas have cured, final inspection tests shall be conducted by the Engineer.

1. Coating thickness specified in microns on ferrous substrates shall be measured with a nondestructive magnetic type dry film thickness gauge such as the Elcometer, manufactured by Gardner Laboratories, Inc.
2. Discontinuities, voids, and pinholes in the coatings will be determined with a nondestructive type electrical holiday detector.
3. Epoxy coatings and thin film coatings shall be checked for discontinuities and voids with a low voltage detector of the wet sponge type, such as Model M1 as manufactured by Tinker and Rasor.
4. Use a non sudsing type wetting agent, such as Kodak Photo Flo, which shall be added to the water prior to wetting the sponge.
5. A high voltage, low current, spark type detector such as Model EP, manufactured by Tinker and Rasor, shall be used for electrical inspection of coal tar enamel only.
6. Tape type coatings shall be inspected for holidays using a device designed for use in detecting such flaws.
7. Pinholes shall be marked, repaired in accordance with the manufacturer's printed recommendations, and retested.
8. No pinholes or other irregularities will be permitted.
9. Coatings not in compliance with the specifications will not be acceptable and shall be replaced and reinspected at Contractor's expense until the requirements of the specifications are met.

3.07 Cleanup

Upon completion of the work, staging, scaffolding, ventilation equipment and containers shall be removed from the site or destroyed in an approved manner. Paint spots, oil, or stains upon adjacent surfaces shall be removed.

3.08 Paint and Coating Schedule

A. The schedule here-in shall indicate the coating system to be used. The list shall not be construed as a complete list of surfaces to be coated, but rather as a guide as to the application of the various coating systems. Surfaces shall be painted except those specifically deleted herein. Where reference is made to ferrous metal in this schedule, it shall not include stainless steel or galvanized metals except as specified in paragraph C.

B. Painting Systems

1. System A

- a. Metals subject to corrosive moisture or atmosphere and condensation.
- b. All metal surfaces shall be sandblasted in accordance with paragraph 3.04 using proper abrasive size to achieve 35 to 40 micron anchor pattern. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed.
- c. Coating shall be applied by airless spray but by brush for small areas. Coating thicknesses shall be:

<u>Component</u>	<u>Minimum Film Thickness</u>
Primer	50 microns
Intermediate Coat	100 microns
Finish Coat	50 microns
Total System	200 microns

- d. Time Between Coatings
 1. A minimum of 12 hours time is required before additional coats may be applied to the prime coat.
 2. Two hours for the intermediate coat.
 3. Two hours for the finish coat.

2. System B

- a. Metals subject to normal indoor or outdoor exposure, except as specified for buildings and not subject to chemical attack.
- b. All surfaces shall be free of dirt, dust, grease, or other foreign matter before coating. Surfaces shall be cleaned in accordance with paragraph 3.04. Weld surfaces and rough edges shall be ground and weld splatter removed.
- c. Coating application shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts, or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application each coat. Coating thickness shall be:

<u>Component</u>	<u>Minimum Film Thickness</u>
Primer	50 microns
Intermediate Coat	50 microns
Finish Coat	50 microns
Total System	150 microns

3. System C

- a. Metals submerged or intermediately submerged in water or corrosive liquid.
- b. All metal surfaces shall be sandblasted in accordance with paragraph 3.04, Near White Blast Cleaning using proper abrasive to achieve 50 to 75 microns anchor pattern. Weld surface, edges, and sharp corners shall be ground to a curve and all weld splatter removed, and welds neutralized with thinner.
- c. Coating application shall be in strict conformance with the manufacturer's recommendations. All sharp edges, nuts, bolts or other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat. Coating thicknesses shall be:

<u>Component</u>	<u>Minimum Film Thickness</u>
Primer	50 microns
Finish Coats (two or more)	400 microns
Total System	450 microns

4. System D

- a. For interior and exterior metal not painted under Systems A, B, and C.
- b. Ferrous metals shall be prepared as specified for System B and galvanized surfaces shall be washed with solvent thinner as recommended by the paint manufacturer
- c. Each coat shall be applied to a minimum dry film thickness of 50 microns
- d. Each coat shall be completely dry before the next coat is applied.

C. Paint Schedule

1. The following schedule shall indicate the coating system to be used. All surfaces shall be painted except those deleted herein and the Engineer shall select the colors.
2. Process Piping Color Code
 - a. All exposed pipe, including tubing, valves, couplings, fittings, flanges, galvanized pipe, and polyvinyl chloride pipe, shall be identified by color code to show its function.
 - b. Painted surfaces shall be color coded in accordance with the coding schedule. Adhesively applied color bands of an approved tape type shall be used on plastic and any other pipe not readily susceptible to painted finish.
 - c. Piping which is not painted shall be provided with 300 mm wide color bands every 3.5 m and each change of direction.
 - d. Labels and arrows showing direction of flow shall be installed on all piping every 3.5 m and at each change of direction of the piping.
 - e. Where not shown or otherwise required by applicable codes and regulations colors and labels shall conform to the following or as selected by the Engineer.

<u>Item</u>	<u>BS 4800</u>	<u>Color Description</u>
Raw sewage	10 B 17	Stone
	14 C 39	(with Dark Green Bands)

Effluent, supernatants and liquors	14 E 39	Medium Green
Final Effluent	14 E 51	Light Green
Potable water	18 E 51	Sky Blue
Air	00 E 55	White
Chlorine	10 E 53	Yellow with danger bands
Gas (methane)	24 O 51	Orange
Electrical conduits	06 E 51	Orange

3. All plant and equipment shall be painted to the colors detailed below unless otherwise instructed by the Engineer.

<u>Item</u>	<u>BS 4800</u>	<u>Color Description</u>
Baseplates and mounting stools	} 00 A 05	Light Grey
Steel handrails, walkways & steel Supporting structures	}	
Fuel storage tanks	06 C 39	Mid Brown
Diesel engines	06 D 43	Light Orange
Screw pumps	} 00 E 53	Black
Non Potable Water Tanks	}	Light Green
Coupling & Fly wheels	} 04 E 53	Red
Drive shafting	}	
Valve handwheels	}	
Lifting equipments, including rails	}	
Beams, bogies, gantry girders	}	
crab, block and control cabin	}	
Centrifugal pumps	} 08 E 51	Mid Yellow
Gearboxes	}	
Transformers	} 18 E 51	Sky Blue
Control, switchgear, distribution & mimic panels	}	
Motors	} 18 E 53	Mid Blue
Alternators	}	
All other exposed metalwork	}	
Shafts and coupling guards	}	Self Color
Aluminium handrailing	}	
Exhaust pipes		Polished Aluminium

D. General Coating System

1. The following list shall indicate the coating system.
2. Piping shall be defined as all pipe, valves, fittings, supports, operating systems and guides.
3. Mechanical equipment shall include all drives, motor control panels, and all other electrical equipment requiring a protective coating.
4. The colors of mechanical equipment shall be as given above.

<u>Item</u>	<u>System</u>	<u>Color</u>
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a.	Pump Station Wet Wells:		
	All exposed mechanical equipment	A	*
	All submerged mechanical equipment	C	Black
	And piping		
b.	Pump Station Dry Wells and Motor Rooms:		
	All mechanical equipment and piping	B	*
	Offices/Store/Workshops all exposed metal	B	*
c.	Miscellaneous:		
	All miscellaneous interior exposed metal surfaces	B	*
	All miscellaneous exterior exposed metal surfaces	A	*
	All submerged metal surfaces	C	Black
	All chambers containing piping	A	*
	Bridge crossing pipework	A	*
	Bridge structural members	A	Black

- Color per equipment or pipe color code schedules.

End of Section 09870

Section 09900: Architectural Painting

Part 1 General

1.01 Description

- A. Provide all labour, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in Contract Documents and as specified herein.
- B. The principle work of this Section includes, but may not be limited to, field painting and finishing of all items of Works, both internally and externally with exception to those items identified in Sections 03350 and 09870.
- C. Painting work shall be executed by an approved specialist Sub-Contractor.
- D. Contractor shall examine other Sections of the Specifications for the various other trades and shall thoroughly familiarize himself with all such items and surfaces to be included in this work which are not included in other Sections.
- E. The term "paint" as used herein, includes paints, enamels, stains, varnishes, lacquers, sealers, fillers and other types of coatings whether used as primers, intermediate or finish coats.
- F. Refer to the schedule of finishes on the Drawings for a list of the areas and surfaces to be painted together with the each painting system, surface preparation, textures and lustre (sheen) required for the various surfaces.

1.02 Shop Painted Items

- A. Shop Primed Items: certain items of work are specified to be shop primed under other individual sections with finish painting specified in this Section.
- B. Shop Finished Items: certain items of work are specified under individual Sections to be shop finished and do not require finish painting in the field.

1.03 Submittals

- A. Manufacturer's Data
 - 1. Manufacturer's specifications and installation instructions for paint materials and systems.
 - 2. Certifications.
 - 3. Verification of mil thickness specified.
 - 4. Other data to show compliance with these Specifications.
- B. Detailed Painting Schedule:
 - 1. "Detailed Painting Schedule" prepared on the basis of:
 - a. Surfaces.
 - b. Types of paint materials.
 - c. Types of primers and sealers.
 - d. Number of coats.
 - 2. List the brand name of the product of the manufacturer for each use.
- C. Samples
 - 1. Samples as hereinafter listed.
 - a. Sample Boards:

1. Colour chips on 300 x 300mm hardboard, with colour, texture and sheen applied to simulate actual conditions.
2. Resubmit sample boards as necessary for selection by the Engineer.
- b. Sample Areas:
 1. Using selected 300x300mm sample boards as a guide prepare a mock-up area and finish partial areas as directed by the Engineer for final approval of colour, texture and sheen.
 2. Approved areas shall serve as the standard for workmanship, appearance and materials for similar areas throughout the project
2. Sample submittal shall be for colour, sheen and texture only.
3. Compliance with all other requirements is the exclusive responsibility of the Contractor.
- D. Paint

Five litres of each type of paint and colour used shall be provided for touch up purposes and shall be handed over to the Employer at the end of the maintenance period.

1.04 Quality Assurance

- A. Where manufacturer makes more than one grade of any material specified, the applicator shall use the highest grade of each type, whether or not the material is mentioned by trade name in these specifications.
- B. Include on labels of all containers the manufacturers name, the product name and number, the colour and the batch number.
- C. All work shall conform to Contract Documents and Section 01400.
- D. Set up mock-ups to enable the Engineer to approve/select colours and finish quality.
- E. Guarantee all exterior paintwork to be weather resistant for a period of 10 years.

1.05 Environmental Conditions

- A. Do not apply paint in rain, fog or mist; when the air is dust laden; when the relative humidity exceeds 85 percent; or when temperature of the surfaces to be painted and the surrounding atmosphere is below 10oC for water thinned coatings and 7oC for other coatings.
- B. Paints, other than water-thinned coatings, shall be applied only to surfaces that are completely free of surface moisture as determined by sight, touch and moisture meter, as specified.
- C. Maintain temperatures at a minimum of 16oC during painting and drying periods.
- D. During period of inclement weather, painting may be continued if areas and surfaces to be painted are enclosed, artificial heat is supplied and temperature and humidity conditions prescribed above are maintained.
- E. Where the paint manufacturer's specifications or instruction differ from the above specifications, the more stringent requirements shall apply to this work.

1.06 Delivery, Storage and Handling

- A. All materials shall be delivered in manufacturer's original sealed containers, bearing the manufacturer's standard label, indicating type and colour. Materials shall be delivered in sufficient quantities in advance of the time needed in order that work will not be delayed in any way.

- B. Materials shall be stored in designated spaces in a manner which meets the requirements of applicable code and fire regulations. When not in use, such spaces shall be kept locked and inaccessible to those not employed under this Section. Each space shall be provided with a fire extinguisher of carbon dioxide or dry chemical type bearing the label of the National Board of Fire Underwriter's or approved equal and tag of recent inspection.

1.07 Protection

- A. Place paint or solvent soaked rags, waste or other materials which might constitute a fire hazard in metal containers and remove from premises at the close of each day's work. Take every precaution to avoid damage by fire.
- B. Protect the work of all other trades against damage, marking or injury by suitable covering during the progress of the painting and finishing work. Repair any damage done. Re-finish any work made necessary by defective workmanship or materials, or carelessness as directed by the Engineer.

Part 2 Products

2.01 General

- A. No claims as to the suitability of any material specified or the Contractor's inability to produce first class work with these materials will be considered unless such claims are made in writing and submitted in sufficient time, prior to the execution of the work, so as not to cause delays.
- B. Provide only absolutely pure linseed oil, turpentine, shellac, and other like materials that are of the highest quality with identifying labels intact and seals unbroken. Use no thinners other than those specified by the manufacturer. Use only primers and undercoats that are suitable for each surface to be covered and that are compatible with the finish coat required.
- C. Use products of the same manufacturer for succeeding coats. Where shop primed materials are to be finished painted and/or prime coat materials are by a different manufacturer than the finish coat materials, confirm compatibility of the primers with the manufacturer of the finish coat paints.

2.02 Materials

- A. Knotting shall be a solution of shellac or other resin in alcohol, pigmented with aluminium or other pigments to be applied on knots in wood before primer complying with BS 1336.
- B. Stoppers or fillers shall be of the following type:
 - 1. For plasterwork - a water-based, powder type and can be mixed with emulsion paint.
 - 2. For concrete or blockwork - cement based material similar to the background and shall be finished with a similar texture.
- C. Raw, refined and boiled linseed oils shall comply with BS 6900.
- D. White Spirit shall comply with BS 245.
- E. Primers shall be as follows:
 - 1. Plaster and concrete surfaces: alkali resistant primer obtained from the maker of undercoat and finishing coat.
 - 2. Alkaline surfaces: special primers obtained from the maker of undercoat and finishing coats.

3. Bituminous surfaces to be finished with oil paint: special primer recommended by the maker of undercoat and finishing coats.
 4. Iron and steel work: red oxide priming paint complying with BS 2523.
 5. External galvanized steelwork: apply a wash coat for the pre-treatment of new galvanized surfaces.
 6. Internal woodwork: approved leadless white or light grey primary paint, compatible with undercoat and finishing coats and obtained from the same maker.
 7. External woodwork: ready mixed aluminium primary paint to comply with BS 4756.
 8. Hardwood: special ready mixed primer obtained from the maker of the undercoat and finishing coats.
- F. Acrylic emulsion paint shall be high build vinyl copolymer type with minimum solid content of 50 percent. Thinner, if recommended, shall be from the same manufacturer.
 - G. Oil paints shall be oil based alkyd enamel paint of flat or silk finish with minimum solid content of 45 percent. Thinner, if recommended, shall be from the same manufacturer.
 - H. Oil alkyd based enamel paint for external galvanized steel work shall be air drying type with undercoat based on a thixotropic alkyd resin. Apply two coats of oil alkyd resin based gloss enamel paint.
 - I. Teak oil shall be of an approved brand and applied in accordance with manufacturer's instructions.
 - J. Varnish shall be of an approved brand.
 - K. Textured paint shall be acrylic-copolymer emulsion based paint suitable for outdoor use. Provide a weather-resistant finish upon drying.

2.03 Compatibility of Coatings

- A. Paints applied in the shop and in the field shall be mutually compatible.
- B. Shop drawings for fabricated items shall indicate manufacturer and type of shop coat to be applied.
- C. Applicator shall determine that the materials specified in the painting schedule are compatible with shop coats to which these materials are to be applied.
- D. Any condition which may require a change in the Specifications shall be brought to Engineer's attention before proceeding with the work. Failure to do so shall be construed as acceptance of the paints specified and the Contractor shall correct at his own expense, any defects in his work resulting from the use of such materials. No claim concerning the unsuitability of any material specified or his ability to produce first class work with same will be entertained.

2.04 Colours

- A. All colours shall be mixed in accordance with manufacturers instructions. Colours shall be pure, non-fading pigments, mildew proof, sun proof, finely ground in approved medium. Colours used on concrete, wallboard surfaces (as applicable), shall be lime-proof. All materials shall be subject to the Engineer's approval.

Part 3 Execution

3.01 Condition of Surfaces

- A. The Contractor shall examine the substrata and adjoining construction, and the conditions under which the work is to be installed. Work shall not proceed until

unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.02 General

- A. Inspect all surfaces in regard to their suitability to receive a finish.
- B. In the event that imperfections due to materials or workmanship appear on any surfaces after the application of paint or coating, the cost of any correction shall be borne by the Contractor.
- C. Remove hardware, switch-plates, trim for mechanical work, lighting fixtures and similar items placed prior to painting. Set aside and re-fix on completion of painting work.
- D. Protect items where not practicable to remove and upon completion of painting work remove protection.
- E. Clean all surfaces to be painted as required to remove dust and dirt. Sand as necessary to properly prepare surfaces to receive paint or natural finish.
- F. Before applying succeeding coats, (minimum 2) primers and undercoats shall be completely integral and shall perform the function for which they are specified.
- G. Properly prepare and touch up all scratches, abrasions or other disfigurements.
- H. Remove any foreign matter before proceeding with the following coat.
- I. All spot-priming or spot-coating shall be feather-edged into adjacent coatings to produce a smooth and level surface.
- J. Do not apply the last and final coats until after other trades whose operations would be detrimental to finish painting have finished with their work in the area to be painted, and the areas have been released for painting by the Engineer.
- K. Comply with the manufacturer's instructions, Engineer's requirements and the following recommendations for the preparation of the listed type of surfaces wherever applicable. Field samples shall be prepared for each different type or colour of paint for Engineer's approval prior to proceeding with the work.
 - 1. Plaster, Concrete and Blockwork
 - a. All splashes of plaster, mortar etc. shall be removed from plastered, concrete surfaces by scraping.
 - b. All holes, cracks, etc. shall be stopped and the whole of the surfaces will be brushed down to remove dust and loose material.
 - c. Plastered surfaces shall receive two coats of linseed oil putty complying with BS 544 well worked in and spread over the entire surface and to be sanded down to give a completely smooth and even surface.
 - d. All traces of mould oil shall be removed from concrete surfaces by scrubbing with water and detergent and rinsing with clean water to remove all detergent.
 - e. When efflorescence has occurred or is suspected, painting shall be postponed for a period as required by the Engineer.
 - 2. Gypsum Board
 - a. Minor imperfections in gypsum board to be painted shall be filled with the same filler used for jointing the gypsum board.
 - b. Whole of the surface shall be brushed down to remove dust.
 - 3. Hardboard
 - a. All dirt and grease shall be removed from the surface.
 - b. After priming all nail holes and other imperfections shall be stopped.
 - 4. Plywood

- a. Surfaces of work to be painted shall be primed, filled as required with a filler, rubbed and dusted down and a second coat of primer applied.
 - b. After final priming all imperfections shall be stoppered, rubbed down and brushed off.
- 5. Woodwork to be Painted
 - a. Before fixing woodwork, all surfaces which will be visible after fixing shall be rubbed. All knots and resin pockets shall be coated with knotting.
 - b. After priming and fixing, all nail holes and other imperfections shall be stopped. Whole surfaces shall be rubbed down and all dust brushed off.
- 6. Woodwork to receive a clear finish
 - a. All holes and other imperfections in surfaces to receive a clear finish shall be stopped.
 - b. Whole surface shall be rubbed down and all dust brushed off.

3.03 Paint Application

A. General

1. All materials shall be used strictly in accordance with manufacturer's instructions and to the approval of the Engineer.
2. Recommended dry film thickness is 75-125 microns/coat or as recommended by the manufacturer.
3. Contents of all cans and containers must be properly and thoroughly studied before and during use and stirred as and when necessary.
4. Paint shall be applied by a brush, roller or spray in accordance with the manufacturer's instructions.
5. All materials when brushed shall be evenly applied with brushes best suited for the type of material being applied. When using a roller, the covers shall be carpet, velvet back or high pile sheet wool best suited for material and texture selected by the Engineer.
6. Sprayed paint shall be uniformly applied with suitable equipment.
7. Spread all materials evenly and smoothly without runs, sags or other defects.
8. Make edges of paint adjoining other materials or colours sharp and clean, without overlapping.
9. Allow sufficient time between coats to ensure proper drying.
10. Sand between coats with fine glass-paper or rub surfaces with pumice stone where required in accordance with manufacturer's directions to produce an even, smooth finish.
11. "Exposed surfaces" shall mean all areas visible when all permanent or built-in fixtures, grilles, access panels, mechanical and electrical equipment housings, ducts and conduits, are in place in all areas specified or scheduled to be painted.
12. Access panels and similar items in painted areas shall be painted to match the areas in which they occur unless otherwise specified in the schedules.
13. Paint the back sides of access panels, removable or hinged covers.
14. Do not paint nameplates on equipment.
15. Wherever steel or other metal parts are shown to be built into and concealed by masonry construction, the Contractor shall paint all such work same as herein specified for exposed parts.

16. Co-ordinate the work with all related trades, so that all finish painting of concealed parts is completed before such work commences.
 17. Do not finish paint exposed parts until after completion of works.
 18. Do not thin the textured paint excessively. Strictly follow the manufacturer's instructions in this regard.
- B. All coatings shall be allowed to dry before application of succeeding coats. All undercoats of oil paints and clear finishes shall be rubbed down to a smooth surface with abrasive paper. All dust must be removed before succeeding coat is applied.
 - C. Each succeeding coat of priming and undercoats shall be sufficiently different in colour as to be readily distinguishable.
 - D. No painting shall be applied to surfaces affected by wet, damp or other unsuitable conditions. External painting work shall not be carried out during inclement weather. Textured paint shall be applied with a perforated roller or as recommended by the manufacturer.

3.04 Protection

- A. Protection of Wet Surfaces: suitable precautions shall be taken to protect surfaces which are still wet by means of screens, barricades and "wet paint" signs.
- B. Protection to Other Trades
 1. Contractor shall ensure that work of other trades are protected from damage and soiling from paint materials.
 2. Movable objects like furniture, equipment, fittings shall be moved, protected and replaced upon completion of an area.
 3. All surface fixed ironmongery, fittings, etc., shall be removed before painting and re-fixed on completion.

3.05 Cleanliness

- A. All brushes tools, etc, shall be kept in a clean condition.
- B. Painting shall not be carried out in the vicinity of other operations which might raise dust.
- C. Do not waste any liquids, slop washings etc. into gullies, manholes, sinks, basins, WCs or any other sanitary fittings.
- D. Suitable receptacles shall be provided by the Contractor to receive such liquids and slop washings.
- E. All flammable residues shall be removed from the site.

3.06 Clean Up

- A. On completion of the work, thoroughly clean the areas affected by painting works.
- B. Remove all paint splashes and smears and surplus construction materials and debris resulting from the work and dispose of same legally off the site.
- C. Carry out touch-up paint work after all equipment has been commissioned but before the building is handed over to the Employer.

End of Section 09900

Section 15101: Valves

Part 1 General

1.01 Scope

This Part specifies the requirements for the design, manufacturer, construction, installation, testing and commissioning of valves and appurtenances.

1.02 Reference Standards

Applicable standards referred to in this section

AWWA C500

AWWA C509

BS 1212

BS 1400

BS 1452

BS 4504

BS 5153

BS 5163

BS 6283

DIN 1693

DIN 3352

DIN 17440

JIS B 2031

JIS B 2032

JIS B 2051

JIS B 2062

JIS B 2063

JIS B 2064

JIS B 2071

1.03 System Description

Valves shall be capable of extended and continuous operation under the specified conditions and at the specified operating pressure.

Part 2 Products

2.01 Valves and Appurtenances - General

- A. All valves shall be suitable for use with water temperature up to 50o C and in climatic and soil conditions encountered in the country of installation. Valves shall be of the same pressure rating as the adjoining pipe, but with a minimum rating of 10 bar. Unless otherwise specified, all valves and appurtenances shall be externally and internally fusion bonded epoxy coated using electrostatic/ fluidized bed process conforming to DIN 30766 or approved equivalent. The coating shall have a minimum thickness of 300 microns, be Holiday-free, non-toxic and colour code RAL 5015. Before application of epoxy coating the surface shall be sand blasted to a minimum SA 2.5 and air blown to ensure a good bond with the epoxy coating. A certificate verifying the suitability of the

epoxy coating for use with drinking water is required from the manufacturer, endorsed by the National Water Council, UK, or a similar independent national body acceptable to the Engineer. Valves shall be supplied complete with flanges, gaskets and stainless steel nuts, bolts, and washers. Flange gaskets shall be of the metal reinforced type. Nuts, bolts, screws and fittings shall be of stainless steel with 2 washers per bolt. Bolt length shall be such that after the joints are made-up, the bolt protrudes through the nut but not more than 12 mm. Unless otherwise detailed or specified here-in, valves shall be supplied complete with stainless steel extension spindles and appurtenances such that the square-nut operator is within 300 mm of the underside of the valve chamber cover slab. Where required, special couplings shall be incorporated to absorb the weight of the extension spindle at no extra cost to the Employer. Stem cap of all valves and square nut operator in case of extension spindles shall be in accordance with BS 5163. One extra stem cap to be supplied for each valve at no extra cost to the Employer. Unless otherwise specified here-in, all attaching hardware of all valves and appurtenances including the nuts, bolts and washers for flanged valves shall be stainless steel.

- B. Marking of valves shall include the; manufacturing standard; manufacturer's name or trademark; nominal diameter (N.D.) in mm; pressure rating in bars; an individual serial number which relates directly to the manufacturer's test certificate; and month and year of manufacture.
- C. All gate and butterfly valves shall be clockwise closing and the direction of opening and closing shall be clearly marked. Position indicators shall be provided on all gate and butterfly valves and shall have adjustable end limit stops at both open and closed end positions to prevent damage by excessive operating force. The maximum effort required to operate the valve against the maximum unbalanced head applied at the circumference of the handwheel or end of the tee-key shall not exceed 15 kg and where necessary gearing shall be provided as specified to achieve this. Handwheels shall be provided for all valves when installed above ground, when operation is within reach. Valves installed deeper than 300 mm shall be provided with an extension spindle and Tee-key. Valves installed out of reach above ground shall be provided with chain drive or remote control drive as shown or specified.
- D. All gate and butterfly valves shall be designed to provide 100 percent water tight shut off at all specified pressures and suitable for installation of electrical actuators when required. Line valves of 300 mm diameter and smaller shall be double flanged gate valves, unless otherwise indicated. Butterfly valves shall be used as line valves for sizes larger than 300 mm diameter and shall be flanged. Where flanges are required they shall be drilled to PN 16 unless specified or directed otherwise.
- E. Valve packing shall be manufactured from pure TFE/PTFE fibres/filament in square plait or multi lock braid construction and shall be lubricated with a suspensoid of TFE/PTFE before braiding and an inert softener/lubricant.

2.02 Gate/Sluice Valves

- A. Gate/Sluice Valves shall conform to the provisions of BS 5163, AWWA C509; JIS B 2062; DIN 3352 Part 4A & B or approved equivalent and as further specified herein. Valves shall be inside screw, non-rising stem, clockwise closing, wedge, gate valves suitable for underground use and flow in both directions. Valves pressure rating shall be equal to, or greater than the adjoining pipe or fitting but a minimum of 10 bar. Valves shall be designed for the "Closed End Test" and shall be of resilient seal design with

bolted bonnet connection and straight-through port. Wedges shall be low clearance - guided in the body and shall have an inner core of ductile iron GGG500 conforming to DIN 1693 or approved equivalent. They shall be encapsulated with a synthetic EPDM rubber covering on the inside and outside by vulcanizing. The rubber covering shall have a minimum thickness of not less than 2.5 mm on both flow sides and 2.0 mm on sealing surfaces with no body-metal exposed. EPDM wedge rubber shall be approved to be used for potable water and be selected to meet the chemical properties and temperatures of the fluid being handled by the valves.

- B. Stems shall be non-rising and manufactured of stainless steel 1.4462 to DIN 17440 or approved equivalent. Stem threads shall be of the rolled type. Sealings and bearings shall be corrosion proof and maintenance-free and shall be designed in the form of a series of 'O' - rings of synthetic rubber. Stem bearing gap shall be sealed against entry of dust by a wiper ring. Stem sealing should be replaced when required. Stem nuts shall be of zinc-free bronze 2.1050.01 to BS 1400 CT 1-C or approved equivalent.
- C. The body and bonnet shall be ductile iron GGG 500/400 to DIN 1693 or approved equivalent and shall be internally and externally fusion bonded epoxy coated as specified here-in. Prior to assembly, the entire valve body and bonnet shall be holiday tested internally and externally at not less than 3.0 kV to DIN 30677 or approved equivalent.
- D. Manual operation shall be by handwheel or by Tee-key as shown on the Drawings. Gear operated valves shall be provided with operating nuts and Tee-keys as specified. Gear cases shall be totally enclosed and equipped with indicators to show valve position and designed for full differential pressure of 10 bars.

2.03 Butterfly Valves

- A. Butterfly valves shall conform to one of the following standards: BS 5155; JIS B 2064; DIN 3354; AWWA C504 or ISO 5752 with a rating equal to, or greater than the adjoining pipe or fitting but with a minimum of 10 bar. They shall be double flanged, short body type with worm type manual operating gear with stem cap and shall be manufactured from the following materials:
 - 1. body and flange : ductile iron/grey cast iron to BS 1452 Grade 260.
 - 2. 2disc : aluminum bronze to B.S. 1400 AB2
 - 3. internal body lining : EPDM rubber bonded to body by vulcanizing.
 - : min. thickness 18 mm for valves of diameter 1000-2000 mm
 - : min. thickness 12 mm for valves of diameter 700-900 mm.
 - : min. thickness 9 mm for those less than 700 mm.
 - : temperature resistant to 100oC.
 - : suitable for use with potable water.
 - 4. shaft and gear spindle : stainless steel 1.4462 to DIN 17440.
 - 5. shaft bearing : self lubricating type with EPDM 'O' ring seals
- B. All the valves shall be of high reliability, of robust design and tropicalized in accordance to the worst prevailing ambient conditions. Valves shall be coated externally with blue colour (RAL 5015) non-toxic polyurethane to a minimum dry film thickness of 150 microns. All the valves shall be designed for no leakage under flow from either direction tested at a differential pressure across the seal of rated working pressure. Each valve shall be subject to a body pressure/leakage test of 1.5 times the design pressure before leaving the manufacturer's works. A certificate showing that any rubber lining used is non-toxic to potable water in accordance to international standards shall be obtained from an internationally recognised authority.

2.04 Air and Vacuum Valves

- A. Air and vacuum valves shall be designed to discharge air during filling of pipelines, admit air during emptying of pipelines and discharge air accumulated at high points in pipelines during normal operation. For both double orifice air valves and single orifice air valves the material of construction shall be:
1. body/cover/dust cover :grey cast iron to BS 1452 grade 220 or approved material,
 2. all working parts :bronze, stainless steel or other non-corroding material,
 3. coating:shall be in accordance with the Particular Specifications.
- B. Detailed catalogues with drawings and graphs showing air inflow/outflow curves shall be submitted for approval. Valves shall be supplied with rubber gasket, stainless steel nuts, bolts and washers.
- C. Double orifice air valve shall combine both large and small orifices within one valve. The large orifice shall be sealed fully and automatically by a buoyant rigid ball. The chamber housing shall be designed to avoid premature closing of the valve by the air being discharged. Small orifices shall be sealed by a buoyant ball at all pressures above atmospheric, except when air accumulates in the valve chamber. Valve will be double flanged drilled to BS 4504 PN 10 pattern and valve construction shall be without integral isolating valve. Valves shall be dynamic type and effective sealing pressure required at valve to give effective sealing shall be 0.1 bar.
- D. Single orifice air valve shall be of screw down type and of 25/50 mm size. Valves shall be supplied with gunmetal cock, gunmetal strap and stainless steel pipe.
- E. Air valves unless otherwise specifically indicated on the drawings shall be of the following type and size depending on the size of pipeline in which they are installed.

Type & Size of Pipe (mm)	Nominal Size of Air Valve (mm)		Type of Air Valve
	Body Size	Flange Size	
Up to 225 PVC	25	Saddle	Single Orifice with an isolating cock, 25 mm BSP Threaded Male ferrule
250 - 300 DI	60	80	Double Orifice with flanged inlet and an isolating Gate valve, (type Stanton N2516 or equivalent)
400 - 600 DI	100	100	Double Orifice with flanged inlet and an isolating gate valve, (type Stanton N2522 or equivalent)
800 - 1200	150	150	Double Orifice with flange inlet and an isolating gate valve, (type Stanton N2525 or equivalent)

2.05 Check Valves

Check valves shall be of lever and weight operated type to BS 5153 or other approved standard with cast iron body, bronze trim and rubber faced. Flanges shall be in accordance with BS 4504 and drilled to BS 4504 Pattern 10.

2.06 Ball or Cylindrical Float Valve (Reservoir Flow Level control Valve

- A. Float valves shall be designed to mechanically and automatically open and close according to the water level in the reservoir.
- B. Float valves shall be the direct action float valve or float operated through a guided bush with vertical shaft fitted to arm.
- C. The valve shall have flanged ends conforming to the working pressure of 10 kgf/cm² for reservoirs. Mating dimension of flange and number of bolt hole shall be according to the manufacturer's recommendation.
- D. Every ball float valve shall be so placed that it is readily accessible for examination, maintenance and operation.
- E. The Contractor shall submit for approval by the Engineer the design data and other engineering information of the ball float valve.
- F. Float valves shall conform to the standards BS 5159 approved equivalent.
- G. Floater shall conform to the standards BS 2456 approved equivalent

2.07 Pressure Reduce Valves

General

The valves shall be General purpose particularly suitable for use with transmission and distribution water lines fitted to which manually controls / reduce a high inlet water pressure to a constant lower outlet pressure, regardless of the flow rate or of the inlet pressure fluctuations.

All valves shall be suitable for use with water temperature up to 40°C and in climatic conditions encountered in the country of installation. Valves shall be minimum rating of 10 bars.

PRV's delivered and installed should conform to the relevant ISTM F 1370/JIS B 8410 or Equivalent BS/ISO standards and should be PN 16 pressure rated.

Design Aspects

Hydraulically operated main valve with pilot operated valve in control system to withstand a predetermined pressure in outlet. The initial setting shall be made by manually adjusted spring using Screw/Bolt & lock Nut. Pressure gauges shall be incorporated to measure the inlet & outlet pressures.

There shall be mechanical means of the valve to isolate the main valve from relay system.

PRV's should be protected from foreign material that may be present in the water by installing a strainer ahead of each PRV. Pressure gauges with isolating valves on the two sides of the PRV should be installed on the upstream and downstream side of the PRV's for setting purposes and checking the operation of valves under service conditions.

Service Condition

Working pressure 16 bar

Inlet Pressure Range 0-10 bar

Inlet flange-faced and drilled to BS EN 1092-2

Downstream Pressure Adjustment-;

Adjustment of outlet pressure to a predetermined constant pressure, at flows varying from the maximum to minimum flow capacity of the valve specified.

Downstream Pressure Adjustment Method-;

The controlling pressure point shall be on the valve and adjustment shall be made by mechanical means.

Main Valve open-closure

Accessories

The main valve shall be able to be closed and opened by closing, the upstream or downstream gate valves.

Test

Body test pressure 16 bar

Assemble Test 10 bar

Material Specification

Main Valve

Body, Bonnet or Cover, Diaphragm disk Spring chamber	Ductile cast Iron GG-40 Grey Cast iron B1452 Cast Iron BS EN 1561 Stainless steel SS 316 or Equivalent
Bonnet, Cover Bearing	Bronze
Valve Seal and Diaphragm	Neoprene base Rubber (NBR)
Valve seal, stem, guide rods and springs	Stainless steel SS 316 or Equivalent
Control Box	-do-

Pilot Valve

Body	DI/Bronze/Stainless steel
Bonnet and pipes	Stainless steel
Rubber Parts	NBR
Fittings	Bronze/ Stainless steel

Technical Literature with the offer

Following literature shall be provided with the offer.

1. Comprehensive catalogues giving dimensions, ratings, operation description and all other technical details.

2. Exploded views showing all components of the assembly.
3. Lists of items with description of items, ratings, sites specifications, materials, standards etc.
4. Detailed spare parts catalogue.

Spare parts

Manufacture recommended spare parts for 5 years for the maintenance of the main valve and relay system shall be provided with the delivery. Cost for same shall be included with valve supply rates.

Itemized price shall be provided with the offer.

Construction Dimension

Construction Dimensions in accordance to EN 588-1 or Equivalent.

Testing

Testing shall be accordance with ISO 5208 or Equivalent.

All valves shall be tested to the appropriate test pressure at the manufacturer's works, and shall be supported by a test certificate from the manufacturer. The Contractor shall Supply the original manufacturer's test certificate. The certificate shall relate to the individual number cast on each valve and shall give the date of test.

Part 3 Execution

Storage and Handling

Storage

- If valves are to be stored in the open for some time, protection should be provided to keep the valves clear of sand and mud.
- Avoid damaging the protective coating.
- They should not be stored in dust laden or saline environments.
- They should be stored at ambient temperature environment.
- The valve sealing areas must be protected as any ingress of sand or foreign bodies will cause damage.

Handling

- The valves should only be lifted using a suitable sling or clamps on the top flange. Fulcrum bracket and lever should not be used as lifting or rigging points for valves or serious damage may occur.
- Avoid damaging the coating protection.
- Sealing faces should be protected throughout.
- The valve is dispatched excluding pressure gauges. The pressure gauges are separately boxed.

Installation and Commissioning

A. Valves shall be installed and commissioned in accordance with manufacture's instructions. The Contractor shall co-ordinate the valve requirements with those of the actuators and instrumentation to ensure compatibility of control interfacing and operations.

B. All valves shall be tested to the appropriate test pressure at the manufacturer's works, and shall be supported by the test certificates from the manufacturer. Work tests on all valves shall be witnessed by an approved independent testing agency at no extra cost to the Employer. The Contractor shall supply the original manufacturer's test certificate endorsed by the approved independent testing agency for each valve supplied. The certificate shall relate to the individual number cast on each valve and shall give the date of the test. The manufacturer shall factory test each valve 600 mm or larger in diameter for performances, leakage and hydrostatic pressure in accordance with AWWA C500.

C. The following minimum steps shall be followed when installation.

- Valves should be installed in sub surface/ vaults with ready access and having adequate space around the valves for maintenance
- Only suitably qualified and experienced engineers/technicians should install and commission valves.
- All special packaging material must be removed.
- Check that all sealing faces are free from damage.
- Check that the pipe line is free from debris.
- To ensure adequate sealing it is important to select the correct type of gasket for the medium concerned.
- Gaskets with the correct flange size must be used.
- The inlet and outlet pipe is in position and permanently fixed, with the machined face perfectly square and with the pipe flange true to the pipe centreline
- Use flange adapter to outlet side to adjustment and easy maintenance & repair
- The assembly is proved to be sitting squarely; the inlet flanged can be bolted up (complete with gasket) in accordance with good flanged bolting practice.
- The correct bolt diameter, length and material for the particular pipe line system being used.
- Tighten bolts loosely.
- Tighten bolts in a diagonal sequence to ensure flanges are pulled parallel.
- Finally tighten bolts to correct torque.
- Assemble Lever and float.
- Check for freedom of movement and alignment.
- The valve sealing areas must be clean and lubricated throughout.
- On final painting, on site, ensure that no paint is applied on the sealing surfaces or the bronze running strips.

D. Commissioning

- The pipeline has been charged, inspect the valve for any leaks and adjust as necessary in accordance with the maintenance instructions.

- Operate valve over full stroke and check for free movement.
- Lubricate all hinge pins and linkages.
- All external debris and foreign matter should be cleaned off from the external surface of the valve.
- Touch up any paint that may have been damaged during installation.
- Adjust the valve to get outlet pressure to predefined value
- Change the inlet pressure and check the performance.

End of Part 15101

Section 15410: Plumbing

Part 1 General

1.01 Scope

This part specifies the requirements for the installation, testing and commissioning of services supplying water for use within buildings. It covers the system of pipes, fittings and connected appliances installed to supply any building with water for ablutionary, cleaning, sanitary and laundry purposes.

1.02 Reference Standards

Applicable standards referred to in this section

BS 417 Galvanised mild steel cisterns and covers, tanks and cylinders: Part 2

BS 864 Capillary and compression fittings for copper tubes and copper alloy.

BS 1010 Specification for draw-off taps and stop valves for water services (screw-down pattern).

BS 1212 Specification for float operated valves (excluding floats).

BS 1968 Specification for floats for ball valves (copper).

BS 1972 Specification for polythene pipe (Type 32) for above ground use for cold water services.

BS 2494 Specification for elastomeric joint rings for pipework and pipeline.

BS 2580 Specification for underground plug cocks for cold water services.

BS 2871 Specification for copper and alloys Tubes.

BS 2879 Specification for draining taps (screw-down pattern).

BS 2505 Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water.

BS 4127 Specification for light gauge stainless steel tubes.

BS 4213 Cold water storage cisterns (polyolefin or olefin copolymer) and cistern covers

BS 4346 Joints and fittings for use with unplasticized PVC pressure pipes.

BS 5114 Specification for performance requirements for joints and compression fittings of use with polyethylene pipes.

BS 5154 Specification for copper alloy globe, globe stop and check, check and gate valves.

BS 5163 Specification for predominantly key-operated cast iron gate valves for waterworks purposes.

BS 5412 Specification for the performance of draw-off taps with metal bodies for water services.

BS 5413 Specification for the performance of draw-off taps with plastics bodies for water services.

BS 5433 Specification for underground stop valves for water services.

BS 5281 Devices without moving parts for the prevention of contamination of water by backflow.

BS 6282 Devices with moving parts for the prevention of contamination of water by backflow.

BS 6437 Specification for polyethylene pipes (type 50) in metric diameters for general purposes.

BS 6572 Specification for blue polyethylene pipes up to nominal size 63 for below ground use for potable water.

BS 6700 Specification for design, installation, testing and maintenance of services supplying water supplying water for domestic use within buildings and their curtilages.

BS 7671 Requirements for electrical installations.

1.03 Cold Water System

The cold water system shall be capable of providing cold water at the locations and in the quantities required and specified. All cold water draw-off points shall be served via a cold water storage system, mounted at high level in each building.

1.04 Hot Water System

The hot water system shall be capable of providing hot water at the locations, in the quantities and at the temperatures required and as specified. Hot water systems shall be of the storage tank type.

Part 2 Products

2.01 General

Every pipe, pipe joint and connected fitting shall be capable of withstanding, without damage or deterioration, sustained temperatures of up to 40°C for cold water installations and up to 70°C, with occasional short-term peaks of up to 100°C to allow for malfunctions, for heated water applications. If pipes, pipe joints or fittings are of dissimilar metals, measures shall be taken to prevent corrosion. Dissimilar metals shall be avoided in below ground installations.

2.02 Pipe Materials

A Copper pipework shall comply with the relevant provisions of BS 2871: Part 1. Copper and copper alloy tube fittings should comply with the relevant provisions of BS 864: Part 2.

B The use and installation of polyethylene pipework shall comply with the relevant provisions of BS 1972 (above ground use), BS 6437 (general purposes) and BS 6572 (below ground use). Copper alloy tube fittings for polyethylene pipes shall comply with the relevant provisions of BS 864: Part 3. Joints for polyethylene pipes shall comply with the relevant provisions of BS 5114 and BS 3505.

C The use and installation of unplasticized PVC pipework shall comply with the relevant provisions of BS 3505. Solvent welded joints and fittings for PVC-U pipes shall comply with the relevant provisions of BS 4346: Part 1. Mechanical joints and fittings for PVC-U pipes shall comply with the relevant provisions of BS 4346: Part 2.

D Stainless steel pipework shall comply with the relevant provisions of BS 4127.

2.03 Draw-off Taps

A Metal bodied taps shall conform to the relevant provisions of BS 5412: Parts 1-5.

B Plastic bodied taps shall confirm to the relevant provisions of BS 5413: Parts 1-5.

C Taps not fixed directly to an appliance shall be screwed into a suitable pipe fitting.

D The fitting, or the pipe immediately adjacent to the tap, shall be firmly secured to a suitable support so as to prevent strain on the pipe and its joints when the tap is operated.

2.04 Stop valves

The use and installation of stop valves shall comply with the relevant provisions of BS 6700. Stop valves fitted to service pipes shall comply with the relevant provisions of the British Standards referenced below. Stop valve components of fittings incorporating stop valves shall comply with the requirements for stop valves. When a stop valve is installed on an underground pipe it shall be enclosed in a pipe guard or chamber under a surface box of the correct grade for the traffic loading relevant to the location.

Nominal Size of Pipe	British Standard	
	Above Ground	Below Ground
50mm or small	BS 1010: Part 2	BS 2580
	BS 2580	BS 5433
	BS 5433	
50mm or larger	BS 5163	BS 5163

2.05 Drain Taps

Draining taps shall comply with the relevant provisions of BS 2879, shall be of the screw down type with a removable key and shall be fixed over a drain or have provision for discharging the water to the nearest convenient point for disposal.

2.06 Ball Float Valves

A Except for interconnected cisterns arranged to store water at the same level, every pipe supplying water to a cistern shall be fitted with a float operated valve or some other equally effective device to control the inflow of water and maintain it at the required level. The inlet control device shall be suitable for the particular application, taking into account the supply pressure and the temperature of the water in the cistern.

B When a float operated valve is used it shall either:

1. comply with BS 1212: Part 2 or 3 and be used with a float complying with BS 1968 or BS 2456 of the correct size corresponding to the length of the lever arm and the water supply pressure; or
2. where any other float operated valve or other level control device is used, it shall comply with the performance requirements of BS 1212 where applicable to the circumstances of its use and shall be clearly marked with the water pressure, temperature and other characteristics for which it is intended to be used.

C Every float operated valve shall be securely fixed to the cistern it supplies and where necessary braced to prevent the thrust of the float causing the valve to move and so alter the water level at which it shuts off. This water level shall be at least 25mm below the lowest point of the warning pipe connection or, if no warning pipe is fitted at least 50 mm below the lowest point of the lowest over flow pipe connection

D Every ball float valve shall be so placed that it is readily accessible for examination, maintenance and operation.

2.07 Servicing Valves

A Servicing valves shall comply with the relevant provisions of BS 6700. They shall be located in accessible positions so as to enable the flow of water to individual or groups of appliances to be controlled and to limit the inconvenience caused by interruption of supply during repairs.

B A servicing valve shall either comply with the requirements for stop valves specified in Clause 2.4 of this Part or shall be capable of withstanding a static pressure 1.5 times the maximum pressure it will be subjected to in use, be leak tight when closed against the latter pressure and, when installed on any pipe pressurised from the mains or on any pipe under a static pressure exceeding 1 bar, shall be operable only by means of a key, screwdriver or coin inserted into a slot on the valve. Screw down servicing valves shall not be of loose jumper design.

C Pipes connecting feed cisterns to primary circuits shall not be fitted with servicing valves where the capacity of the cistern does not exceed 18 litres. A servicing valve shall be fitted upstream of, and as close as practicable to, every float operated valve connected to a supply pipe.

D Every pipe taking water from a cistern of capacity exceeding 18 litres shall be fitted with a servicing valve close to the storage cistern, tank or cylinder.

E Having regard to the hydraulic resistance of screw down type valves, it is permissible for copper alloy gate valves complying with BS 5154 to be used for this purpose. Specially designed spherical plug valves are available in the smaller sizes and are well suited for fitting near to single outlet fittings and appliances as servicing valves.

2.08 Backflow Protection Devices

A Pipe interrupters for backflow protection shall comply with the relevant provisions of BS 6281: Part 3.

B Vacuum breakers for backflow protection shall comply with the relevant provisions of BS 6282: Part 2 and 3.

C Check valves for backflow protection shall comply with the relevant provisions of BS 6282: Part 1. Any additional installation instruction issued by the manufacturer or supplier of the check valve shall also be complied with.

D Combined check valve and vacuum breaker for backflow protection shall comply with the relevant provisions of BS 6282: Part 4.

E Double check valve assembly for backflow protection shall comply with the relevant provisions of BS 6282: Part 1, with a draining tap complying with the relevant provisions of BS 2879 connected between them.

2.09 Cold Water Storage Tanks

A Cold water storage tanks shall impart no taste, colour, odour or toxicity to the water nor promote or foster microbial growth under the conditions where the cistern is going to be installed. Cold water storage tanks shall be constructed in accordance with the following:

1. galvanised mild steel complying with the relevant provisions of BS 417
2. polyethylene complying with the relevant provision of BS 4213.

B The tank shall be supported on a firm level base capable of withstanding the weight of the cistern when filled with water to the rim.

C Any tank with an effective capacity of up to 1000 litres shall be fitted with a warning type overflow pipe. Tanks with an effective capacity exceeding 1000 litres shall be fitted with one or more overflow pipes. For capacities up to 5000 litres the lowest overflow pipe shall be a warning pipe. For capacities exceeding 5000 litres, either the lowest pipe will be a warning pipe, or a device shall be fitted that gives an audible or visual alarm when water in the tank reaches a level at least 50mm below the lowest point of the lowest overflow pipe. Overflow pipes shall be made of rigid corrosion resistant material. No overflow or warning pipe shall rise in level outside the cistern. Warning type overflow pipes shall discharge water immediately the water in the tank reaches the overflow level and shall discharge to a conspicuous position, outside the building where this is appropriate. The overflow pipe or pipes should be able to convey water away from the tank at a rate equal or greater than the rate of flow of water into the tank. Notwithstanding, warning type overflow pipes shall be not be less than 20mm in diameter.

2.10 Hot Water Storage Tanks

A Hot water storage tanks shall be constructed in accordance the relevant provisions of BS 843 and the following:

1. galvanised steel tanks shall comply with the relevant provisions of BS 417: Part 2 of BS 1565
2. copper tanks shall comply with the relevant provisions of BS 699, BS 1566: Part 1, BS 1566: Parts 2 or BS 3198.
3. cast iron tanks shall comply with the relevant provisions of BS 1563
4. pressed steel sectional tanks shall comply with the relevant provisions of BS 1564.

B A cistern type storage water heater incorporating a cold water feed cistern shall be so located that the water heater base is higher than the level of the highest outlet to be served and gives adequate flow at the outlets.

C Unless otherwise stated, the temperature of the stored water shall never exceed 65°C.

D Every vessel shall be fitted with a thermostat acting on the heat input and in addition, every hot water storage vessel of capacity greater than 150 litres shall be fitted with an automatic control capable of stopping and starting the heat input to the stored water at pre-set

times. A pressure relief valve shall be incorporated into the system, be mounted on the top of the tank and be vented to a suitable position.

2.11 Central Hot Water Systems

A The following central hot water systems shall comply with the relevant provisions of BS 6700:

1. direct vented system
2. indirect vented system
3. direct un-vented system
4. indirect un-vented system.

B Pumped circulation shall be provided in all cases where the natural circulating pressure available is insufficient to circulate the water through the system. Immersed rotor (glandless) type circulating pumps shall be used on primary circuits only. Pumps for boosting or secondary circulation shall be adequately resistant to corrosion. Inlet and outlet connections to a circulating pump shall be fitted with fullway valves. Circulating pumps shall be quiet in operation. The circulating pump shall be installed in accordance with the manufacturer's recommendations and space shall be allowed for maintenance and removal. Circulating pumps shall comply with the relevant provisions of BS 1394.

2.12 Insulation

A General

1. Thermal insulating materials shall comply with BS 5422 and BS 3958 where applicable.
2. Thermal insulating materials shall be applied in accordance with the manufacturer's recommendations. They shall be kept dry before, during and after application, except for water which may be required for the purpose of mixing. Gaps shall not be left at the joints of the insulating materials.
3. Where necessary, insulating material shall be resistant to or shall be protected by suitable covering against mechanical damage, rain, moist atmosphere, subsoil water and vermin.
4. Examples of suitable materials of insulating purposes are:
 - a. polyurethane foam
 - b. foamed or expanded plastics
 - c. corkboard
 - d. amoliated vermiculite.

B Pipes

1. While insulating material shall be continuous over pipes and fittings, it shall be finished in such a manner as to allow access to valves for operation.
2. Where cold water pipes pass through areas of relatively high dew point, eg habitable areas, they shall be insulated to prevent condensation forming on them.
3. Pipes in hot water supply systems that exceed the maximum lengths given below, shall be thermally insulated in accordance with BS 5422.

Outside diameter of pipes (mm)

Maximum length (m)

12	20
Over 12 up to and including 22	12
Over 22 up to and including 28	8
Over 28	3

C All hot water storage vessels shall be thermally insulated so that heat loss under normal operating conditions shall at no time exceeds 90 W/m² surface area.

2.13 Electrical Immersion Heater and Storage Vessel

A Storage type electric water heaters incorporating one or more thermostatically controlled immersion heaters shall use suitable storage vessels provided with adequate feed and expansion arrangements.

B The storage vessel shall be constructed so that water delivered is not liable to become contaminated to the extent that it is hazardous to health or is unfit for its intended use.

C The storage vessel shall be corrosion resistant.

D The immersion heater or heaters shall comply with the relevant provisions of BS 3456.

E All electrical controls, including thermostats, cut-outs and switches, shall comply with the relevant provisions of BS 3955.

2.14 Filters

A Filters shall be able to remove the following:

1. harmful bacteria
2. giardia cysts
3. chlorine tastes and odours
4. sediment to 1 micron.

B Filters shall have the following characteristics:

1. inhibit the growth of bacteria and other micro-organisms
2. easy to inspect, clean and maintain.

C Filters shall not unduly affect distribution rates.

Part 3 Execution

3.01 Pipe Installations

A Pipe runs within buildings should not be laid exactly horizontal but to a slight fall to reduce the risk of air locks forming.

B In installations that do not have limited straight runs and many bends and offsets, allowance for expansion and contraction of the pipes shall be made by forming expansion loops, by introducing changes of direction to avoid long straight runs or by fitting proprietary

expansion joints. This is particularly important where temperature changes are considerable and where the pipe material has a relatively large coefficient of expansion.

C In installations with limited straight runs and many bends and offsets, thermal movement is accommodated automatically.

D Where a pipe enters a building it shall be accommodated in a sleeve that has previously been solidly built-in and the space between the pipe and the sleeve shall be filled with non-hardening, non-cracking, water-resistant material for a minimum length, of 150 mm at both ends to prevent the passage of water, gas or insects.

3.02 Concealed Pipework

A Concealed pipework shall be housed in properly constructed builders work ducts or wall chases and have access for maintenance and inspection. Ducts and chases should be constructed as the building structure is erected and should be finished smooth to receive pipe fixings. No pipe or joint in or under a building shall be embedded in any wall or solid floor or in any material below a solid floor at ground level except for the following:

1. the enclosing of any pipe and associated pipe joints in a purpose made duct or chase in a solid floor in such a way that the pipe and pipe joints can be exposed for purposes of examination, repair or replacement without endangering the structural integrity of the building
2. the enclosing of any pipe and associated pipe joints in a purpose made chase in a solid wall (but not within the cavity of a hollow wall) in such a way that the pipe and pipe joints can either be capped off and isolated or be exposed for purposes of examination, repair or replacement without endangering the integrity of the building
3. the enclosing of any pipe and associated pipe joints in any internal wall that is not a solid wall
4. the enclosing of any pipe but not joints within a purpose made pipe sleeve or duct in or under any solid floor in such a way that the pipe may be removed and replaced, and the provision of an inspection access point at each joint.

B No pipe or pipe joint shall be located under floorboards or a suspended floor, at ground floor level unless every pipe and pipe joint is accessible for examination. Where access panels are formed in floor panels of structural chipboard or plywood, the structural stability of the building shall not be affected.

C All pipe laid in ducts shall be adequately supported by clipping as specified in Table 1

3.03 Pipe Fixings

A Iron pipe shall be secured by heavy weight holder bats of iron or low carbon steel either built in or bolted to the structure.

B Copper and stainless steel piping shall be secured by copper, copper-alloy, plastics clips or brackets.

C Steel piping shall be secured by steel copper alloy, suitable plastic clips or brackets. Copper clips or brackets shall not be used for fixing steel piping.

D Plastic piping shall be secured by suitable metal, plastic clips or brackets. Allowance shall be made for free lateral movement within the clips and brackets.

E Piping that is insulated shall be secured on clips or brackets that allow sufficient space behind the back of the pipe and the batten or wall to which the pipe is fixed for the insulation to be properly installed.

F The spacings for fixings for internally located piping shall be in accordance with:

Type of Piping	Nominal Size of Pipe ¹	Spacing on horizontal run (m)	Spacing on vertical run (m)
Copper (light gauge and stainless steel complying with ISS 2871: Part 1 or BS 4127: Part 2)	15	1.200	1.800
	22	1.800	2.400
	28	1.800	2.400
	35	2.400	3.000
	42	2.400	3.000
	54	2.700	3.000
	76	3.000	3.600
	108	3.000	3.600
	133	3.0000	3.600
	159	3.6000	4.200
Copper (heavy gauge) complying with BS 2871: Part 2	15	1.800	2.400
	22	2.400	3.000
	28	2.400	3.000
	35	2.700	3.000
	42	3.000	3.600
	54	3.000	3.600
	76	3.600	4.500
	108	3.900	4.500
	133	3.900	4.500
	159	4.500	5.400

Type of Piping	Nominal Size of Pipe ¹	Spacing on horizontal run (m)	Spacing on vertical run (m)
Unplasticized PVC ² complying with BS 3505	$\frac{3}{8}$	0.530	1.060
	$\frac{1}{2}$	0.610	1.220
	$\frac{3}{4}$	0.685	1.370
	1	0.760	1.520
	$1\frac{1}{4}$	0.840	1.680
	$1\frac{1}{2}$	0.915	1.830
	2	1.065	2.130
	3	1.370	2.740
	4	1.525	3.050
	6	1.830	3.660
Polyethylene	$\frac{3}{8}$	0.300	0.500
	$\frac{1}{2}$	0.400	0.800
	$\frac{3}{4}$	0.400	0.800

	1	0.400	0.800
	1 ¹ / ₄	0.450	0.900
	1 ¹ / ₂	0.550	0.900
	2	0.550	1.100
	2 ¹ / ₂	0.600	1.100
	3	0.700	1.200
	4	0.700	1.400

1. Nominal size of pipe for copper and stainless steel is in millimetres. Nominal size of pipe for uPVC and polyethylene is in inches.
2. These figures are based on an ambient temperature of 20°C. For other temperature ranges the pipe manufacturer should be consulted.

3.04 Pipework Jointing

- A Jointing of pipes shall be in accordance with the relevant provisions of BS 6700
- B All proprietary joints shall be made in accordance with the manufacturer's instructions.
- C Care shall be taken to establish satisfactory jointing techniques for all water service pipework. All burrs shall be removed from the ends of the pipes and any jointing materials used shall be prevented from entering the water system
- D All piping and fittings shall be cleaned internally and be free from particles of sand, soil metal filings and chips etc.
- E Jointing systems using elastomeric sealing rings shall be Type W, complying with the relevant provisions of BS 2494, and shall be obtained from the pipe manufacturer.

3.05 Installation of Stop Valves, Gate Valves & Draining Taps

An adequate number of valves and draining taps shall be provided so as to permit the various sections of the installation to be isolated and drained down. The following rules shall apply to all installations:

1. A stop valve shall be fitted to the main at a height of 1 metre above the point of entry into the building
2. a draining tap shall be fitted to the main immediately above the stopvalve.
3. a stop valve shall be provided to the main as close as possible to the storage cistern
4. a gate valve shall be provided to the down supply pipes from all cold water storage cistern, as close as possible to each cistern
5. a stop valve shall be provided to the branch supply pipe for each range of sanitary fittings at the junction with the main down supply.
6. a draining tap shall be provided at the lowest point of each branch supply pipe to enable the whole of the installation to be drained.

3.06 Installation of Water Storage Tanks

A Where possible and practicable, tanks shall be positioned in locations where they can be easily accessed for inspection, cleaning and maintenance.

B Tanks positioned outside buildings shall be provided with covers and a suitable shade.

C Each tank shall be fitted with a 25 mm diameter outlet for connection to a drain pipe. The outlet shall be flush with the bottom of the tank. The floor of tank shall be laid at a slight fall towards the outlet. A drain pipe and a stop-tap shall be fitted to the outlet. The drain pipe shall be run to a point as detailed in the Project Specification or shown on the Project Drawings.

D Every pipe supplying water to a cistern shall be fitted with a float operated valve or some other equally effective device to control the inflow of water and maintain it at the required level.

E Distribution pipes from tanks shall be connected so that the lowest point of the outlet is not less than 50 mm above the bottom of the tank.

F Connections to distribution pipes feeding hot water apparatus shall be set at a level of at least 25mm above connectors to pipes feeding cold water outlets.

3.07 Testing

A The Contractor shall notify the Engineer at least one working day before of his intention to test a section of pipeline. Unless otherwise stated by the Engineer, both interim and final tests shall be undertaken on each section of the Works. The Contractor is responsible for providing water for testing purposes and for its disposal on completion of testing.

B The timing of tests shall be arranged as follows:

1. interim test: as soon as practicable after completion at a particular section, with particular attention to all work which will be concealed
2. final test: to be carried at a completion of all work on the water services and prior to handing over
3. re-tests: items failing any test shall be corrected immediately and re-tested before further work proceeds.

C The Contractor shall note that satisfactory completion at an interim test does not constitute a final test.

D Visual inspection shall be carried out at both interim and final testing in order to detect faults in construction or material not shown up under test but which could lead to premature failure. A careful record shall be kept of such inspections. All internal pipework shall be inspected to ensure that it has been securely fixed. All cisterns, tanks, hot water cylinders and water heaters shall be inspected to ensure that they are properly supported and secured, that they are clean and that cisterns are provided with correctly fitting covers before testing takes place.

E When the installation is complete and visual inspection has been satisfactorily completed, it shall be slowly filled with water, with the highest draw-off point open to allow air to be expelled from the system. The installation, including all cisterns, tanks cylinders and water heaters, shall then be inspected for leaks.

- F The system shall be hydraulically tested in the following way:
1. subject the pipes, pipe fittings and connected appliances to a test pressure at least 1.5 times the maximum working pressure for a period of at least 1 hour
 2. check the installation for leaks; including all cisterns, tanks, cylinders and water heaters.
- G Each draw-off tap, shower fitting and float-operated value shall be checked for flow against specified requirements. Performance tests shall also be carried out on any specialist items to show that they meet the requirements detailed.

3.08 Disinfection

A All hot water systems and cold water systems installed shall be disinfected before being taken into use. For installation with more than one cistern, all cisterns shall be cleaned and chlorinated simultaneously as described below.

B All visible dirt and debris shall be removed from the cistern. Then the cistern and distributing pipe work shall be filled with clean water and then drained until empty of all water. The cistern shall be filled again and the supply closed.

C A measured quantity of sodium hypochlorite solution of known strength shall be added to the water in the cistern to give a free residual chlorine concentration of 50 mg/l in the water.

D The cistern shall be left to stand for 1 hour. Then each draw-off fitting shall be successively opened working progressively away from the cistern. Each tap or draw-off fitting shall be closed when the water discharged begins to smell of chlorine. The cistern shall not be allowed to become empty during the operation; if necessary it shall be refilled and chlorinated as detailed above. Should refilling be necessary, the cistern and pipes shall be left for a further hour before continuing the disinfection procedure.

E The tap furthest from the cistern shall be opened and the level of free residual chlorine in the water discharged from the tap shall be measured. If the concentration of free residual chlorine is less than 30 mg/l the disinfecting process shall be repeated.

F Finally, the cistern and pipes shall remain charged with chlorinated water for at least 16 hours and then thoroughly flushed out with clean water until the chlorine concentration at the taps is no greater than that present in the clean water from the supply main.

End of Section 15410

Section 16010 : General Provisions for Electrical Installations

Part 1 General

1.01 Description

A The Electrical Installation Contractor, herein referred to as the 'Contractor' within this section and all other Divisional Sections of this specifications shall carry out all electrical works complete in accordance with the requirements of the Contract Documents.

B Scope of Work

1. The supply and installation of all services, equipment, components, accessories and fittings required for the operation of the facility to the extent specified and detailed on the Drawings and Specifications including one year maintenance after provisional hand-over.
2. Builder's work in connection with the electrical installations, including supply, necessary inserts and sleeves.
- 3 Any work which can be reasonably inferred as necessary for the safe, satisfactory operation of each system, whether such work is specified or shown on drawings or not.
- 4 The supply and installation of cables, conduits, boxes and termination points, for the motors, starters, controls and the like for the process equipment, illumination, heating, ventilation and air-conditioning and plumbing services.
- 5 Arranging for installation of permanent electrical supply by the supply authority, including submission of all necessary documents and carrying all necessary approvals.
- 6 Attending upon the supply authority installing mains power supply.

C Documentation

- 1 The indication and/or description of any item on the Drawings or in the Specification, unless otherwise specifically stated, imply an instruction to supply and fix such items.
- 2 Drawings show the general arrangement of cables, raceways, etc. and the approximate location of equipment and utilities. Symbols and schematic diagrams do not carry any dimensional significance.

1.02 Quality Assurance

All supplies and services offered in response to this specification shall conform to the latest standards. The design, equipment and installation requirements shall comply with the standards and recommendations laid down by the following:

- 1 Requirements for Electrical Installations (IEE Wiring Regulations) as issued by the Institution of Electrical Engineers, London/ British Standards Institution.

- 2 Standards relating to Electrical Installations and equipment as issued by International Electro-technical Commission.

1.03 Submittals

A Shop Drawings

- 1 Provide shop drawings, to a scale not smaller than the corresponding layout drawings, showing the following:
 - a Exact runs and sizes of conduits, ducts, cables, cable trays and trunking.
 - b Layout drawings for each separate electrical installation showing the actual locations of points, suitably identified, the locations of switchgear, switchboards, motor control centers and distribution boards, details and types of fittings.
 - c Plans showing the equipment assembly, space requirements, clearances and locations for cable entrances and anchor bolts.
 - d Elevations showing all parts, devices, components and nameplates, positions and arrangements of the equipment. Show as many elevations as necessary to clearly depict component and device arrangements.
 - e Schedules of points, indicating how the various outlets are connected to the distribution boards, size of circuit wiring, the rating of the protective device and the type and size of appliance of fitting.
 - f Schematic diagram of connections of distribution boards, and equipment to main switchboards showing sizes of feeders, etc.
 - g Schematic and elementary wiring diagrams, of each unit of each equipment, showing numbered terminal points, numbered wires and numbered interconnections to other equipment and remote devices.
 - h Connection diagrams, of each unit of each equipment, showing numbers belonging to individual terminal points, wires and interconnections to other equipment and remote devices.
 - i Complete catalog information of all parts and components of electrical equipment.
 - j All cable routings and layouts for the different electrical services, feeders and branch circuits showing routes, sizes and types of cables.
 - k Any other data necessary for the proper maintenance of the installations.
- 2 An over current protective device coordination study that shows all protective devices to be properly coordinated shall be submitted with the equipment shop drawings for approval.
- 3 Final coordination of electrical works with mechanical, structural and architectural work shall be carried out from complete shop drawings and sufficient time shall be allowed for coordination and checking of shop drawings and calculations after shop drawings are submitted.
- 4 Individual shop drawings shall bear a stamp indicating that the work has been coordinated with other trades.

B Progress Drawings

- 1 Provide and keep on the job at all times, one complete and separate set of blackline prints of the electrical work on which shall be clearly, neatly and accurately noted, promptly as the work progresses, all architectural and electrical changes, revisions and additions to the work. Whatever work is installed different to what is shown on the Contract Drawings, shall be recorded.
- 2 Indicate daily progress on these prints by colouring in the various conduit, ducts, trunking, cable trays, fixtures, apparatus and associated installation works erected.

1.04 Job Conditions

- A. It is required to lay conduits etc. for the electrical works in advance of casting concrete slabs and construction of walls. Before commencing builder's work in connection with electrical installation, Engineer's approval for the related shop drawings coordinated drawings shall be obtained. Approval for the materials shall be obtained prior to the work commencement.
- B. Before the permanent electricity supply is connected the electrical installations must be complete, tested and approved by the Engineer and the supply authority. An Inspection and Test Certificate issued by a Chartered Electrical Engineer registered with the supply authority shall be submitted in this regard.

1.05 Segregation of Services

A Electrical services shall be segregated as specified throughout the installation to obviate the following:

- 1 Electrical interference from one circuit to another.
- 2 A fault on one circuit affecting another.
- 3 Unnecessary fire damage.
- 4 Difficulties in circuit identification.
- 5 Voltage limits for general safety.

B All raceways shall be kept clear of other services except where intentionally earthed or bonded. Generally, raceways shall be kept 150 mm away from and above hot water and 75 mm away from other services.

C Unless specifically indicated otherwise, normal, emergency, low voltage cables & wiring shall be segregated throughout the installation generally in the following manner:

- 1 Armoured and Sheathed Catalyst : Where more than one tray has been specified or is necessary to accommodate the number of cables on a run, where practical, segregation shall be achieved by dedicating each tray to either normal or emergency services. Where normal and emergency cables have to run together in trays, ducts or trenches, they shall be formed in two groups, one normal and one emergency.
- 2 Insulated Conductors: Insulated conductor circuits shall, where possible, be segregated throughout by enclosing in separate conduits, trunking or trunking compartments.

1.06 Delivery, Storage and Handling

The Contractor shall include for packing, shipment and delivery to site of all equipment and materials necessary for the completion and satisfactory working of the installation. Each item shall be adequately protected and packed and be clearly marked to ensure the safe conveyance and delivery to site.

Part 2 Products

2.01 Materials

- A All equipment and materials used in the electrical installation work shall be new and of the highest quality to the best modern practices. All materials shall be approved types, supplied by approved manufacturers and shall be fully suitable for use in the conditions stated.
- B All electrical materials and equipment shall comply in all respects (design, properties, qualities, testing, etc.) as a minimum with the latest International Electrotechnical Commission recommendations and/or the latest British Standards. Should there be any difference between the IEC/BS and this Specification, then the most stringent requirements shall apply.
- C Component parts of similar use and rating shall be interchangeable with each other.
- D All manufactured items shall be the product of manufacturers regularly engaged in producing works of the types specified and be constructed and finished by the same manufacturer.
- E All manufactured items shall be free from imperfections and defects which may impair their durability and serviceability or affect their appearance.

2.02 Labels

- A For substations, switchgear, switchboards, motor control centers and panel boards engraved lamacoid name plates, black with minimum 6 mm high white lettering.
- B For Distribution Boards and Circuit Breakers :
 - 1 Where individually enclosed or in substations, switchgear, switchboards, motor control centers and panel boards without doors engraved lamacoid nameplates, black with 3 mm high white lettering.
 - 2 In panel boards with doors mount directories in transparent plastic covers in metal frames.
- C Wiring Identification

- 1 Identify wiring with permanent indelible, wrap-around, identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
- 2 Maintain phase sequence and colour coding throughout.
- 3 Colour code to standards above as specified elsewhere.
- 4 Use colour coded wires in communication cables, matched throughout system.

D Conduit and Cable Identification

- 1 Colour code conduits and metallic sheathed cables.
- 2 Code with plastic tape or paint and points where conduit or cable enters wall, ceiling or floor, at 15 m intervals.
- 3 Colours to be 25mm wide prime colour and 20mm wide auxiliary colour to standards above.
- 4 Number code, per Circuit Schedule, all feeder and branch circuit cables at both connection points and in manholes, handholes, pull-boxes and junction boxes with fibre or non-ferrous metal tags, fastened with non-ferrous wire.

E Device Plates

For Device Plates of local toggle switches, toggle switch type motor starters, pilot lights and the like, whose function is not readily apparent plates to be engraved with 3mm high letters describing equipment controlled or indicated.

F For Busbars

- 1 Phase identification letters shall be stamped into the metal of the busbars of each phase of the main buses in each substation, switchgear, switchboards, motor control center and panel board in addition to color identification.
- 2 Letters shall be visible without disassembling current carrying of supporting elements.

G For Doors

Where switchboard rooms, cable chambers, metal screened spaces and the like contain electric power cables, bus bars or equipment operating at voltages exceeding 600 V : enamelled sheet metal, red on white, reading "Danger - High Voltage".

H For Rooms

To switchboard rooms, electric closets, metal screened spaces assigned to electrical equipment, and the like: enamelled sheet metal, red on white, reading "Electrical Equipment Room - No Storage Permitted".

2.03 Fabrications

Steel frames and like components shall be thoroughly cleaned to remove all scale, rust, oil and grease, treated with an approved rust inhibiting solution

and painted with two undercoats and one coat gloss finish before leaving the factory. Supply an adequate quantity of paint for final touching up on site.

2.04 Standard Products

Where two or more units of the same class of equipment are required, these units shall be product of a single manufacturer and interchangeable.

2.05 Mounting Height of Accessories

A Unless indicated otherwise, the mounting height of accessories shall be as indicated below. Mounting heights shall be measured between the centre line of the item concerned and the finished floor level.

B The following is the schedule of mounting height:

- 1 Lighting switches, equipment and appliance control switches and regulators, including the manual controls of heating and ventilation systems, pushbuttons, and any other item containing manual controls for the operation or regulation of any system or facility, shall be mounted at 1200 mm above finished floor level, unless indicated otherwise.
- 2 Socket outlets shall be mounted at 300 mm other than in kitchens and switchrooms. The sockets above any work bench, where socket outlets shall be mounted at 1200 mm above finished floor level.
- 3 Telephone outlets shall be mounted at a height of 300 mm, wall mounted telephone outlets shall be mounted at a height of 1200 mm above finished floor level.

2.06 Accessories

- A Accessories installed throughout the Contract Works shall, unless indicated otherwise, match in colour, style and manufacture. Situations where this is impracticable shall be brought to the Engineer's attention prior to work being put in hand.
- B The cover plates of flush-mounted accessories shall be fixed square and flush with the building surface.

2.07 Finishes

Shop finish metal enclosure surfaces by removal of rust and scale, cleaning, applications of rust resistant primer inside and outside and at least two coats of finish enamel.

2.08 Fixings

- A Unless indicated elsewhere in the Specification or on the Drawings, the Contractor shall provide and make all fixing to the Facility for all services included in this Contract.

- B Rawl bolts or similar approved fixings shall be used for heavy loads. Plastic or fibre plugs shall be used for light loads. Other proprietary methods may be specified later in this Specification. The Contractor may offer alternative methods to those specified but the Engineer reserves the right to reject such alternative and call for the use of the specified methods only.
- C All metal fixing devices shall be zinc or cadmium plated, sheradized or hot dipped galvanized including any expansion shields, plugs, nuts, washers, etc., associated with the fixing devices.
- D The Contractor shall carry out any drilling and plugging for screw fixings of pipe work, raceways, cable trunking, ducting, wiring, conduit fittings, accessories and finishing trims supplied under this Contract.
- E Generally equipment and supports shall be fastened to:
- 1 Solid masonry or plastered surfaces by suitable anchors, screws and bolts.
 - 2 Poured concrete by expandable inserts.
 - 3 Hollow masonry walls or suspended ceilings by patent retention type fastenings. The Contractor shall establish that there is adequate strength in such hollow material before fixing to same.
- F Supports or equipment installed by other trades shall not be used except with the permission of the other trades and approval of the Engineer.
- G Purpose made fixing clips and brackets may be necessary in certain areas and the Contractor shall be deemed to be aware of this at the time of tendering and to have included for the supply and fixing of same in this Tender Bid.
- H Details of proposed clips and/or brackets shall be submitted to the Engineer for approval, prior to the manufacture of same being commenced.
- I Holes shall not be drilled in any structural steelwork or pre-stressed concrete without first obtaining the approval of the Engineer.
- J Where it is proposed to use cartridge fired bolts for fixing to block-work or concrete, approval shall first be obtained from the Engineer. The ruling also applies to stud welded fixing on steel structures.
- K All supports or mountings described above, shall be steel, hot dipped galvanized after fabrication wherever practicable. In cases where the Engineer agrees that it is not practical to provide galvanized steel, supports and mountings shall have two coats of rust resistant paint applied.

Part 3 Execution

3.01 Labelling

- A For switchgear, switchboards, motor control centres and panel boards, fix on front, externally by riveting
- B For distribution switches, motor starters and circuit breakers
 - 1 Nameplates on individually enclosed units and units in switchgear, switchboards, motor control centres and panel boards without doors, fix on front externally.
 - 2 Directories in panel boards with doors, fix on inside frame of door.
- C "Danger - High Voltage" Signs - fix on external face of doors of switchboard room, cable chambers, metal screened spaces, and the like containing electric power cabling.
- D Primary Gear
 - 1 Fix a stencilled "mimic bus" diagram on front face.
 - 2 Diagram shall show schematically the primary bussing and switching arrangement.
 - 3 Primary gear containing switching equipment whose blades are alive when open shall have warning signs to that effect.
- E Outlet boxes, junction boxes and cabinets - when used in conjunction with empty raceways for wires of a future system, mark indelibly on the inside denoting the system.

3.02 Workmanship

- A The entire work provided in this specification shall be constructed and finished in every respect in a workmanlike and substantial manner. The Contractor shall provide the system in accordance with the best trade practice and to the satisfaction of the Engineer.
- B Keep others fully informed as to the shape, size and position of all openings required for apparatus and give full information sufficiently in advance of the work so that all openings may be built in advance. Provide and install all sleeves, supports, etc., hereinafter specified or required.
- C Obtain detailed information from the manufacturers of apparatus as to the proper method of installing and connecting same. Obtain all information from others which may be necessary to facilitate work and the completion of the whole project.
- D Provide the services of an experienced foreman, who shall be continuously in charge of the erection of the electrical work, together with all necessary skilled workmen, helpers and labourers, required to properly unload, transfer, erect and connect up, adjust, start, operate and test the system.
- E Before installing any work, verify that it does not interfere with clearance required for other work. Notice of adverse conditions shall be forwarded in writing to the Engineer before any work in question is installed. If notification is not made, and work installed causes

interference with the contemplated design, make such changes in his work as directed by the Engineer to permit the installation of all work of the project, at no additional cost to the Employer.

- F Raceways shall be run as straight and direct as possible in general forming right angles with or parallel with walls or piping and neatly spaced, with risers erected plumb and true, maintain a clearance of at least 25mm between finished coverings and adjoining work. Approved ceiling height shall be obtained from Architectural Drawings.
- G All equipment and accessories shall operate without objectionable noise or vibration. Should operation of any of the equipment or systems produce noise or vibration which is, in the opinion of the Engineer objectionable, make change in equipment and do all work necessary to eliminate the objectionable noise or vibration at no additional cost to Ministry of Environment & Energy.
- H Wherever possible services shall not cross expansion joints. Where this is unavoidable the services shall accommodate the design movement without damage, by use of approved expansion couplings/flexible conduit arrangement.

3.03 Protection

A The Contractor shall be responsible for his work and equipment until finally inspected, tested and accepted, carefully store materials and equipment which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material.

B Protect work and material of other trades from damage that might be caused by his work or workmen and make good damage thus caused.

3.04 Layout of the Work

- A The electrical drawings show the general arrangement of the work and the approximate locations of equipment. Refer to all other drawings to verify all spaces and conditions affecting work of this section. The construction of the facility in certain places may disclose the inaccessibility of equipment apparatus if placed in locations shown on the drawings.
- B Where departures from the drawings are deemed necessary, details of such departures and reasons therefore shall be submitted to the Engineer for approval.
- C No such departures shall be made without prior written approval of the Engineer.

- D Conduit and ducts shall be run in wall chase, recesses, pipe shafts and ceilings except where indicated otherwise. Arrange work accordingly.
- E All equipment and apparatus such as motors, switchgear, switchboards, motor control centres, panels, controls etc., shall be installed as to be readily accessible for operation and maintenance.

3.05 Protection

- A Protect exposed live equipment during construction for personnel safety.
- B Shield and mark live parts "LIVE 400 VOLTS"
- C Arrange for installation of temporary doors for room containing electrical distribution equipment. Keep these doors locked except when under direct supervision of an electrician.

3.06 Fireproofing

- A Establish from Drawings where fire and smoke barriers exist, and make adequate provision of fire and smoke barriers in and around trunking, conduits, cables, etc., where they pass through floors and fire rated walls, and where inert gas smothering systems are installed pack space between wiring and sleeve full with suitable material and seal with caulking.
- B The Contractor shall ensure that this work is carried out such that the integrity of any such fire barrier is properly maintained where pierced by electrical services.

3.07 Spare Parts

- A General
 - 1 Submit to the Engineer a list of, and provide, all spare parts to be required for a further one year operation from the issue of the Taking-Over Certificate.
 - 2 Spare parts required include but not necessarily limited to those listed below and shall be increased where increased quantities for each item or equipment are recommended by the manufacturer.
 - 3 Store spare parts in a location designated by the Engineer.
- B Main Low Tension Boards
 - 1 2% MCCB of all different frame sizes, but in any case not less than two circuit breaker of each size.
 - 2 5% spare indicating lamps for each indicating lamp in the switchgear.
 - 3 One set of tools required for switchgear maintenance.
 - 4 Provide complete spare parts as recommended by the manufacturer for different sizes of ACB.
- C Switchboards, Motor Control Centres and Distribution Boards
 - 1 5% spare combination magnetic motor starters
 - 2 5% spare for different ratings of MCCB
 - 3. 5% spare HRC fuses for different ratings

- 4 5% spare of isolators of each size
- 5 5% spare RCCB of each size
- 6 5% spare MCB of each size

D Circuit Accessories

- 1 Wall Switches - provide five percent of the number of each size and type of wall switch installed.
- 2 Socket Outlets - provide five percent of the number of each size and type installed.
- 3 Lamps - provide five percent lamps of each size and type for indicating panels and pilot lights installed for different systems.

E Lighting Fixtures

- 1 2% of the total quantity of each type of lighting fixture. This quantity shall not be less than one fixture of each type.
- 2 Additional diffusers for 5% of the total quantity of each type of lighting fixture provided with acrylic, plastic or glass enclosures. Diffusers shall be identical to those of the installed fixtures. This quantity shall not be less than two diffusers of each type.
- 3 10% spare lamps of each wattage of different types
- 4 5% percent of the total quantity of control gear (ballasts) of each type and size but in no case less than (6) ballasts of each size and type

G The Tenderer shall submit with his offer detail prices of the spare parts he is required to provide under the Contract indicating the quantity and the unit rate of each item.

3.08 Testing and Commissioning

A General

- 1 The Engineer shall be authorised to inspect, examine and test at any reasonable time and in the premises of the manufacturer the quality of the material used for the equipment to be supplied.
- 2 Should part of the equipment be subcontracted to another manufacturer, the Contractor shall ensure that the Engineer is authorised to inspect, examine and test the equipment in the premises of the Sub-Contractor.
- 3 These inspection, examinations and tests shall not relieve the Contractor in any case from this contractual responsibility and commitments.
- 4 The Contractor shall notify the Engineer in writing at least 15 days beforehand of the date and place at which any equipment shall be available for tests to be made according to the provisions of the Contract. Should the Engineer not have appeared at the place indicated within ten days following the date indicated by the Contractor, the latter shall proceed with the tests and it shall be deemed that they had been witnessed by the Engineer. The

Contractor shall send the Engineer duly certified copies of the results of the tests.

- 5 The Engineer shall notify the Contractor of his intentions to attend the test 24 hours beforehand.
- 6 Should the Contract provide for tests to be made in the premises of the Contractor or any Sub-Contractors or Suppliers, the Contractor shall afford any assistance, labour materials, electricity, fuel supplies, equipment and instrument required and which can be reasonably requested for these tests.

B Testing

On completion of the entire electrical installation work or any separate or distinct part thereof, the Contractor shall

- 1 Notify the Engineer, in writing, that the complete part of the electrical work is ready for inspection. Before doing so, perform initial trial tests, correct, adjust, balance, regulate, etc., the section concerned as necessary until required conditions are obtained.
- 2 The inspection of the Contractors work shall be carried out in the presence of the Engineer and in accordance with the requirements Part 7 Inspection and Testing of BS 7671: 2001, Requirements for Electrical Installations, I.E.E. Wiring Regulations Sixteenth Edition.

1. Inspection shall comprise of but not limited to:

- a. Connection of Conductors
- b. Identification of Conductors
- c. Routing of cables against mechanical damage
- d. Selection of conductors for current carrying capacity and voltage drop
- e. Connection of single-pole devices for protection or switching in phase conductors only
- f. Correct connection of accessories and equipment
- g. Presence of fire barriers, suitable seals and protection against thermal effects
- h. Methods of protection against electric shock
 - i. Protection against both direct and indirect contact
 - ii. Protection against direct contact
 - iii. Protection against indirect contact
- i. Prevention of mutually detrimental influence
- j. Presence of appropriate devices for isolation and switching
- k. Presence of under voltage protective devices
- l. Choice and setting of protective and monitoring devices
- m. Labelling of protective devices, switches and terminals
- n. Selection of equipment and protective measures appropriate to external influences
- o. Adequacy of access to switchgear and equipment
- p. Presence of danger notices and other warning signs
- q. Presence of diagrams, instructions and similar information
- r. Erection methods

2. Testing shall comprise of but not limited to:

- i. Continuity of protective conductors

- ii. Continuity of ring final circuit conductors
- iii. Insulation resistance
- iv. Site applied insulation
- v. Protection by separation of circuits
- vi. Protection against direct contact by barrier or insulation provided during erection
- vii. Insulation of non conducting walls and floors
- viii. Polarity
- ix. Earth electrode resistance
- x. Earth fault loop impedance
- xi. Prospective fault current
- xii. Functional testing

The results and readings obtained shall be equal or better than the requirements of the IEE and the supply authority regulations and these shall be recorded on forms similar to Model Forms for Certification and Reporting given in the Appendix 6 of BS 7671 : 2001.

- 3. Supply all instruments and tools required for carrying out the tests.
- 4. Follow-up and make all necessary arrangements with the supply authority for the purpose of providing permanent electricity supply. Also provide all facilities and attendance to the supply authority for any other tests carried out before energising the installation.

End of Section 16010

Section 16450 : Earthing System

Part 1 General

1.01 Description

This Section shall include all labour, materials and accessories for the complete performance of the earthing systems in accordance with the Specifications and Drawings.

1.02 Quality Assurance

The earthing system shall be in accordance with the supply authority's rules and regulations and to BS 7671.

1.03 Submittals

Shop Drawings

- 1 Submit full technical details and conductor size calculations of each type of cable or wire proposed.
- 2 Submit exact route of each cable or wire proposed.

Part 2 Products

2.01 Materials

- A Products used in the earthing system shall be copper or an approved copper alloy, unless otherwise specified, and specifically manufactured for the purpose.
- B Earth Continuity Conductors
 - 1 Sizes shall be not less than half that of the associated phase conductors.
 - 2 Insulation shall be of the same material as insulation in associated sub-circuits.
- C Main Earth Loops - 25 x 3 mm tinned copper tape, unless otherwise indicated.
- D Rod Electrodes
 - 1 Shall be the earth rod electrode type, unless impracticable to drive deep into the particular soil.
 - 2 Earth rod electrodes: 16mm diameter steel core copper jacketed type, comprising a high strength steel alloy core with a molten welded copper covering.
 - 3 To be 3.6m long, in 1.2m sections coupled by strong bronze couplers.
- E Plant Electrodes - to be either
 - 1 Copper; or
 - 2 Cast iron where artificial treatment of soil is necessary because of high soil resistivity.

- F Earth Connectors shall connection of rod electrodes: bolted type.
- G Removable Earth Links - to comprise a bolted copper link fixed on porcelain insulators and complete with studs, nuts and washers to take the earth tape and a bolted lug adequately sized for the final connection of the earth electrode.
- H Bolts, Washers and Nuts in Bolted Connections: High copper alloy or silicone bronze. Ferrous hardware is not acceptable.
- I Earth Pit Cover
 - 1 Shall be of heavy duty cast iron cover.
 - 2 Shall have a recessed lifting hook.
 - 3 Shall have a brass plate, engraved "Electrical Earth Below".

Part 3 Execution

3.01 Installation

- A Circuit Wiring
 - Shall have a green and yellow coloured insulated earth continuity cable connecting the earth bus or earth terminal in switchboards, switchgears, motor control centers and panel boards to the motor, equipment, outlet and device earthing lugs.
- B Main Earth Loops
 - 1 Fix in mechanical equipment rooms and other areas indicated on the drawings, in convenient locations, allowing two return paths to earth.
 - 2 Fix copper tape to structure with copper or brass saddles and/or screws. Make tees and straight joints by riveting and seating, welding or brazing.
 - 3 Make branch connections between main loop and major equipment, such as switchboards, switchgears, motor control centers and large motors, with copper tape of same size as main loop tape.
 - 4 Make other branch connections to equipment with copper conductors of size not less than half that of the relative phase conductor.
- C Removable Earth Links
 - 1 Fix in every main earth lead to enable the electrode system to be disconnected for testing.
 - 2 Install in an accessible position, above ground as close as possible to the earth electrode.
- D Exposed Earth Cables
 - Install and locate to provide maximum mechanical protection, utilizing ceiling corners, suspended ceiling and webs of beams as much as possible.
- E Bolted Connections
 - 1 Multiple bolt type.
 - 2 Where bare copper is bolted in connections contact surfaces shall be silver electroplated.
- F Brazed Connections

Where earthing terminal connections are to be brazed to equipment, thoroughly clean metal prior to brazing and repaint impaired surfaces to prevent corrosion.

G Connections Between Dissimilar Metals

Protect by

- 1 Painting with a moisture resistant bituminous paint or compound, or
- 2 Wrapping with protective tape to exclude moisture.

H Equipment Earthing

- 1 Connect all non-current carrying metallic parts of the electrical/mechanical installation to the earthing system.
- 2 Non-current carrying metallic parts of the electrical installation include:
 - a Metal conduit cable armour (steel and aluminium) raceways, outlet boxes, cabinets, and the like.
 - b Exposed metal parts of apparatus.
 - c Enclosures, doors, grilles, barriers and the like protecting or shielding electrical equipment from direct access.
- 3 Series earthing of one piece of equipment to another is not acceptable.

I Fire fighting equipment shall be earthed on a separate ring system.

J Motors Earthing

- 1 Connect the motor terminal box to the relative earth loop. The terminal must be mechanically connected to the frame or, where this is not feasible.
- 2 Extend the earthing conductor through an insulated bushed opening in the connection box and connect to the frame.

K Main Switchboards, Switchgears And Motor Control Centers Earthing

- 1 Connect the special earthing lug or busbars inside the cabinet to the main earth copper tape.
- 2 Connect all parts of the switchboards, switchgears and motor control centers other than "live" parts, to the earth bar in the board in an approved manner.

L Connect an earthing conductor from the main distribution earth busbar to an earth connector welded to the cabinet and earthing bushings on the incoming and outgoing feeder conduits.

M Bus-Duct Feeders Earthing

Connect the green coded earth busbar directly to the earth bus-bar in main switchboard with earth copper tape.

N Connect steel and aluminium armour to the earthing system.

O Earth Rod Electrodes

- 1 Drive extensible rods of the same diameter into the ground, either manually or by power driven hammer, to a suitable depth to obtain low resistivity in the particular soil.
- 2 Weld earth connectors to the top of the rods, in sufficient number to make connection with all incoming cables.

- P Earth plate electrodes shall be used where ground resistivity is low but increases with depth or it is not possible to go deep into soil. Terminations shall be protected against corrosion.
- Q Construct a small concrete pit 1130 x 30 cm, complete with removable heavy gauge cast iron cover with recessed lifting hook, at the head of the earth rod, to protect the rod and allow access to connections for testing.
- R Telephone earth shall be either by means of steel cored rods or G.I. pipes but shall be isolated from the general earth. The earthing lead shall be bonded to the MDF. The earth resistance shall be one ohm or less. The size of the earthing lead shall be not less than 10 mm². All the earthing for the positive pole of any PABX and other low voltage equipment shall be taken from the telephone earth. This earth shall be kept isolated from the electrical earth.
- S Lightning Protection
 - 1 Lightning air terminals and down conductors for lightning air terminals shall be provided and shall be min of 15 mm diameter tinned copper (air termination rod) 0.8 metre long with top spike. Roof conductors and down conductors shall be of PVC sheath 3 x 20 mm copper tape or copper conductor size 50 mm² PVC colour to be approved by the Engineer.
 - 2 Air termination rods shall be securely anchored and welded. Down conductors shall be run along the outer surface of the wall or column of the building. Down conductors shall be as short as possible protected and directly connected to earth pit. Anchoring bolts shall be used to hold roof conductors and down conductors in firm position. Lightning conductor connectors shall be provided for conductor splice connections and conductor terminal connections. The connectors shall be heavy duty, cast metal and shall have hex-head screws in the bodies and holes in the tongues for bolts. Handrail and structures in the vicinity of the lightning protection system, if any, shall be bonded to the system by 50 mm² PVC sheath copper.
 - 3 Suitable concrete earth pit and cover supplied by the same lightning protection system manufacture shall be provided.
- T Testing
 - 1 Testing earth electrode resistance by earth resistance tester.
 - 2 The resistance of the earth electrode shall not exceed 10 ohm.
 - 3 Install additional earth electrodes if these figures are not met.

End of Section 16450

Section 16500 : Lighting

Part 1 General

1.01 General

This section includes the supply and installation of lighting fittings as shown on the Drawings and described in the Particular Specifications.

1.02 Reference Standards

Applicable standards referred to in this section:

BS 800	:Radio Interference
BS 1853	:Tubular Fluorescent Lamps for General Lighting Service.
BS 2818	:Part 2 Fluorescent Chokes
BS 3677	:Mercury Vapour Bulbs
BS 3772	:Fluorescent Starters
BS 4017	:Capacitor
BS 4533	:Lamp Fittings
BS 4782	:Mercury Vapour Chokes
BS 6702	:Tube and Starter Bases

1.03 Quality Assurance

Design Criteria:

- 1 Lighting fittings shall be of first class quality, made by approved manufacturers and shall be suitable for trouble free operation on the system voltage at the site.
- 2 Lighting fittings shall be complete with internal wiring between lamp holder and termination point. Wiring shall be in silicone rubber insulated flexible cables of appropriate sizes.
- 3 The Contractor shall be responsible for coordinating the work of this Section with the components of ceiling systems specified under Division (9) of this Specification.
- 4 All lighting fittings shall be complete with accessories and fixing hardware necessary for installation whether detailed under fixture description or not.
- 5 Outdoor lighting fittings shall be installed at mounting heights as specified or instructed on site by the Engineer.
- 6 All outdoor lighting fittings shall be suitably constructed and protected to withstand corrosive atmosphere and high ambient temperature of the site, whether indicated under the fittings description or not.
- 7 Lighting fittings shall have power factor not less than 0.9
- 8 All light fittings shall be earthed.

1.04 Submittals

A Products Data

- 1 Fluorescent fittings and other electrical discharge lamp fittings, submit:
 - a full technical details of the fittings, including the control gear, indicating the type and size of materials used in construction;
 - b relevant sheets of manufacturer's catalogues and dimensional drawings of the fittings, clearly showing the location of the component;
 - c wiring diagram of international connections indicating color, size and type of wiring;
 - d confirmation that control gear is suitable for prolonged and continuous service in the ambient conditions described in Section ;
 - e the power factor under operating conditions and illumination data sheets;
 - f type and quality of any plastic materials used in the fittings.
- 2 Other lighting fittings, submit:
 - a full technical details of the fittings, with relevant manufacturer's catalogues and illumination data sheets;
 - b type and quality of all metal finishes;
 - c size and quality of all glassware.
- 3 At least one piece of each of the lighting fixtures originally specified shall be submitted and displayed at the project office for comparison in the event an alternate make is offered unless otherwise specified.

Part 2 Products

2.01 Lamps

- A Lamps shall be furnished and installed in all lighting fixtures covered under the Contract.
- B Lamps used for temporary lighting services shall not be used in the final lamping of fixture units.
- C Lamps for permanent installation shall not be placed in the fixtures until so directed by the Engineer, and this shall be directly before the building areas are handed over.

2.02 Fluorescent Lamps

- A Tubular fluorescent lamps: to BS 3677, sizes as indicated.
- B Tube color: cool white, unless otherwise indicated.
- C Fittings shall comply with BS 800: 1983 for suppressing radio frequency interference.

2.03 High Pressure Mercury Vapour Lamps

A Wattage as indicated.

B Color: Deluxe white

C Lumen output of lamp after 100 burning hours shall not be less than:

50W	:	2000 lumen
80W	:	3850 lumen
125W	:	6500 lumen
250W	:	14000 lumen

D Burning position: Universal

2.04 Control Gear for Fluorescent Lamps

High frequency electronic ballasts not less than 25 kHz to IEC 928

2.05 Lamp Holders

A According to BS 5042 and BS 6702.

B SBC, BC GES, Bi-pin, etc. as necessitated by the lamp cap.

C Edison screw lamp holders: to be designed so that the lamp cap only makes electrical contact when fully screwed home and to have means to prevent the unscrewing of the lamp due to vibration or similar cause

D Lamp holders for fluorescent lamps shall be the spring loaded rotor type for use with bi-pin lamp

2.06 Outdoor Lighting

A Compound lighting shall involve the supply and installation of lamp posts with energy saving lamps, underground distribution and the relevant control and distribution boards as shown on the Drawings.

B Lamp posts shall be as detailed in the Particular Specifications or as shown on the Drawings.

C The general layout for the conduits shall be clearly shown on the Contractor's submittal. Conduits shall be PVC.

D The distribution and control boards for the facility lighting shall have lamp circuit controlled by timer and photo cell switches at the location shown on drawing. All control switches for the lighting circuits shall be permanently and legibly labelled. Override switch shall be provided to enable manual switching for individual circuits.

2.07 Lighting Fittings

All lighting fittings shall conform to BS 4533 and shall be supplied complete with appropriate control gear where necessary, lamps, mounting and fixing accessories etc. whether explicitly mentioned in the description of each light fitting or not. All the fittings shall have the same appearance, material, technical details and approximate dimensions.

Part 3 Execution

3.01 Lighting Installation

Terminations:

- 1 General fluorescent fittings mounted direct to conduit outlet boxes shall have the circuit wiring run direct to the fittings terminal position. Provide flexible conduit pigtail for all fixtures to J-box.
- 2 Terminations for recessed or semi-recessed pattern fittings fitted in false ceilings shall have the circuit wiring terminal above the ceiling in a ceiling rose outlets mounted adjacent to the fitting.

3.02 Installation of Lamps

- A Install lamps in all lighting fixtures at substantial completion.
- B Do not use lamps used for temporary lighting in the permanent installation.

End of Section 16500

Particular Specifications

Section 01010

PS 1.01 Description of the Works

- A. The Government of Republic of Maldives has appointed the Ministry of Environment and Energy as the Implementing Agency for the Design of Water supply facilities in Eight Islands including Lh.Naifaaru. The work comprises construction of Desalination Plant, Admin Building , service reservoir, pumping stations and distribution pipelines.
- B. This contract, includes the construction of distribution systems, desalination Plant,Service Reservoir and Pump House.The work includes the furnishing of all labour, materials, plant and equipment necessary and as shown and specified
- C. The contract also includes:
 - testing and commissioning of the works;

PS 1.02 Contractor's Use of Site

- A. All construction operations and facilities over the entire lengths of the contract shall be confined to within the highway or road rights-of-way boundaries and facility sites unless otherwise approved by the Engineer and the relevant authorities.
- B. All such areas shall also be designated and treated as included within the definition of the word "Site". Unless identified in the Contract as to be demolished, the Contractor shall be responsible for safeguarding all utilities and structures (including but not limited to drainage dikes, head walls, culverts, bridges, abutments, distance marker posts, signs and fences) and the like in the vicinity of the Site and shall ascertain from the private and public utility authorities positions of all existing underground services and shall maintain and protect or divert them as required. At least one lane of traffic shall be maintained over the entire length of the road.

PS 1.03 Drawings

- A. The Drawings forming a part of the Contract Documents are listed in Volume IV
- B. Compliance with Drawings
 - 1. All work, during its progress and upon completion shall conform to the lines, elevations and grades as shown on the Drawings
 - 2. Contractor shall complete the proposed work in every detail as shown or specified.
 - 3. Should any detail or details be omitted from the Drawings and Specifications which are essential to its intended completeness, then it shall be the responsibility of the Contractor to design such detail and then furnish and install Works so that upon completion, the Work will be acceptable, operational and ready for use.

C. Further drawings may be issued to the Contractor by the Engineer as work progresses.

D. Interpretive Drawings

1. Any additional drawings which the Contractor requires to interpret the drawings for the use of his employees shall be prepared by the Contractor.
2. Four copies of each shall be supplied to the Engineer, if required by him.

E. The Employer accepts no responsibility for any omissions or the correctness of the representation of existing features on the Drawings.

PS 1.04 Local Conditions

A. These data are provided as an indication of the type of conditions in which the Contractor's plant will have to operate and particular attention should be paid to concrete curing and corrosion conditions. In the event of the Tender being awarded to the Contractor, he shall satisfy himself as to the accuracy of the information provided.

B. The site conditions shall be taken as follows:

Max Monthly Average Temperature	29.5 0C
Min. Monthly Average Temperature	23.6 0C
Ambient Humidity Range	70 - 85 %
Wind Velocity	33.5 m/s
Yearly Rainfall	1,500 to 2,200 mm
Altitude Range (above M.S.L.)	0 to 4 m
Traffic Loading	HA

C. Hoarafushi is an island in the Maldives, 316.95 km (196.94 mi) from the capital, Male and situated at Coordinates: 6°58'50" North latitude and 72°53'45" east longitude. The Length of Hoarafushi is 1.75 km (1.09 mi) and Width is 0.45 km (0.28 mi). The total area of Hoarafushi is (0.691 km²), Hoarafushi is an inhabited island of Haa Alif Atoll, Maldives and is geographically part of the northern-most atoll in the country, Ihavandhippolhu Atoll. It is an island-level administrative constituency governed by the Hoarafushi Island Council. The latest population based on 2014 census is estimated at 1826 inhabitants. Population growth is estimated around 1.5 percent with a total 2317 figure in 2030.

Languages : Divehi, English

Ethnic Group : Dhivehis

Religion : Islam

Section 01041

PS 1.05 Project Co-ordination

The Contractor shall co-operate with the Ministry of Environment and Energy, other contractors, private and public utility organizations and with the Atoll Council, Atoll Office with regard to the execution of work, connections to the work, delivery of materials and co-ordinate with them subject to approval of the Engineer.

Proper coordination has to be ensured at the time of fixing such connections, backfilling and compacting the trenches.

PS 1.06 Notification to Residents, Business and Public

The Contractor shall hand deliver to each residence and business premises in close proximity to the works, a written notice three days in advance of commencing any construction work, including delivery of pipe, which will involve temporary inaccessibility or water shutdown to their properties. Said notice shall state when operations will start and approximately when they will end. The notices shall be printed on A4 paper with wording similar to that shown as follows in Tamil, and with translation in Sinhalese and English. In addition, the Contractor shall post, no further than 1 kilometre apart, signs on posts placed (a minimum of 600 mm below ground and surrounded with 150 mm of concrete) 1.4 m above ground with the same wording in all languages as directed by the Engineer. The notice shall be laminated to protect it from rain, securely fastened to a sign board and securely fastened to the post.

NOTICE

To The People Along This Road

Within the next few days, work will be started on the installation of a water main in this road as part of the project for improvement of Water Supply.

We should complete the work by.....

This work may cause some inconvenience but will be of permanent benefit.

We will appreciate your co-operation in the following:

- *Please be alert when driving or walking in the construction area:*
- *Tools, materials, pipe and equipment are attractive to children. For their safety, please keep them away from the construction site;*
- *Please report all inconvenience to the job superintendant or call the office at the number given below.*

This work is being performed for the Ministry of Environment and Energy for the benefit of the Horafushi consumers in particular, by:

(Insert name, address and telephone number of the Contractor in this space)

We will endeavor to complete this work as rapidly as possible and with a minimum of inconvenience to you.

Signed:

Title:

Section 01043

PS 1.07 Details of Contractor's Supervisory Staff and Subcontractors

The Contractor shall employ sufficient technical personnel as specified in personnel qualification criteria and provide within 14 days of the Letter of Acceptance of the Works, the

name, age, nationality, working language and degree of proficiency, official position in the firm and title, qualifications, memberships in technical organizations; and professional experience for each employment held including employer; name and description of work, projects and location; and position held in the project for all key staff . These shall include the Project Manager, Site Engineer, Land and Quantity Surveyors, Technical officers, Safety Officer. Secondary staff shall be CAD Operators/Draftpersons, and Administrative Manager. The names shall be the same names submitted for key personnel at the site for each position with the qualification documents and with the Tender. No substitution of key personnel shall be permitted except in exceptional circumstances, and only with the permission of the Engineer.

The measurement for the Contractor's Management services shall be done in months as per the details submitted by the Contractor giving evidence for engagement of such personnel for the works in the particular month. The Contractor shall submit the detail breakdown of the monthly rate provided for the key staff provided above, the salaries and allowances paid. The vehicles, housing and other facilities provided to personnel specified will not be considered as expenditure under this item and shall be included under overhead and profit of the contractor incorporated in unit rates of other items in the B.O.Q.

The payment will be made as per the monthly rate approved by the Engineer under the provisional sum item provided in the B.O.Q.

PS 1.08 Plant Record

The Contractor shall provide the plant proposed in the pre-qualification document. If the plant to be supplied is different than that proposed, he shall obtain approval of the Engineer prior to shipment to Maldives and provide the reasons for the substitution and details of ownership or lease. A detailed comparison shall be made by the Contractor between the original and substitute plant and equipment. The substitute shall be equal or better than that originally proposed. If the Contractor ships his equipment without approval, he may be required to remove it from the country, at his own expense, and provide the equipment originally proposed or an approved substitute, again at his own expense, to the site.

PS 1.09 Overtime Working

- A. Whenever working outside the normal hours is proposed, the Contractor shall request approval from the Engineer giving not less than two working days notice.
- B. Some Times Contractor has to work outside the normal hours is proposed, in order to instructions given by the Atoll Office, Atoll Council and other relevant authorities. In such cases all additional expenses to the contractor should be boren by him.
- C. The Engineer's inspection staff is to be compensated for the additional time at a negotiated rate, mutually agreed, for the overtime work which will be deducted from the next or following payment due the Contractor.

PS 1.10 Daily Programme

- A. The Contractor shall furnish a daily programme for the following working day before the close of each site where the Contractor is working on each working day. The programme shall include the following:
1. work to be executed during normal working hours only;
 2. location of the area of the site where work will be carried out;
 3. proposed labour and Contractor's equipment and supervision to be provided.
- B. The Contractor shall be responsible for safety on site and shall take all necessary precautions for the safety of workers, visitors and the public alike. He shall provide for all costs and charges incurred by complying with all safety, health and welfare regulations pertaining to all employees, visitors and the general public including those employed by, or on the site at the request of, sub-contractors. The Contractor shall attend to the protection and temporary covering and/or barricading of open excavations, trenches, pits and other hazards to safety to satisfy all whether all lighting condition
- C. The Contractor shall file with the Engineer, the names, addresses, and contact numbers of representatives who can be contacted at any time in case of emergency. The representatives shall be fully authorized and equipped to correct unsafe or excessively inconvenient conditions at short notice.
- D. The Contractor shall programme and execute the works in such a manner to maintain access to existing residences and businesses at all times as far as is practicably possible.

Section 01050

PS 1.11 Field Datum

The following data have been used to produce the information shown on the Drawings from the Survey Department national datum based on the national grid values:

Section 01090

PS 1.12 Abbreviations

AC	:	Atoll Council
AO	:	Atoll Office

Section 01200

PS 1.13 Pre-Construction Conference

The pre-construction conference shall be held at the office of the Ministry of Environment and Energy.

Section 01300

PS 1.14 List of Submittals

The Contractor shall submit a list of all submittals showing the forecast date for submission of each item at the commencement of the Contract. Extension of time will not be granted because of the Contractor's failure to make timely and correctly prepared and presented submittals with allowance for checking and review periods as specified in Section 01300. Unless otherwise specified, initial submittals shall be made within 56 days from the Letter of Acceptance of the Works.

PS 1.15 Foundation Drawings

The Contractor shall, within the times named in the Specifications or in accordance with the programme, provide Drawings showing the manner in which the equipment is to be fixed together with all information relating to the works, required for:

1. Preparing suitable foundations and anchoring facilities;
2. Providing suitable access for the equipment to the point on site where the equipment is to be erected;
3. Making all necessary connections to the equipment (whether such connections are to be made by the Contractor under the Contract or not).

PS 1.16 Record Documents

- A. The Contractor shall maintain one record copy of all Drawings, Specifications, Addenda, Variations, Approved Submittals, Correspondence and Transmittals at the Site in good order and readily available to the Employer the Engineer and the Engineer's representative.
- B. In addition to the requirements of the Technical Specifications, Record Documents shall be clearly and correctly marked and the Record Specifications annotated by the Contractor to show all changes made during the construction process at the time the changed Work is installed and the Works as executed complete with:
 1. existing & finished levels
 2. National Grid coordinates;
 3. profiles of all pipelines larger than 100 mm diameter;
 4. dimensions;
 5. reinforcing steel details;
 6. details of supports left in place;
 7. locations of all services and underground utilities encountered;
 8. locations of all structures including reservoirs, tanks, buildings, chambers & appurtenances including those existing features not to be demolished;
 9. invert and cover levels of all chambers;
 10. connection details and locations;
 11. details of pipe materials and bedding;
 12. sizes and types of manhole and access covers
 13. any other information requested by the Engineer.
- C. Draft Record Documents shall be submitted to the Engineer for his approval, and then finalized in accordance with any amendments required by him. Record Document submission shall be as specified in the Specifications and shall include:
 1. four bound sets of "As-Built " Record Drawings on paper to A1 size;
 2. four bound sets of "As-Built " Record Drawings on paper to A3 size;

3. one set of first copy mylars (negatives) to A1 size;
 4. two sets of compact disks containing the record drawings and all operation and maintenance manuals in MS Word and Autocad, or other approved format. The Engineer will make available to the Contractor an electronic copy of the tender drawings and specifications;
 5. two legal copies of the all the software used on the compact disks, registered in the name of Environment and Energy.
- D. Each drawing shall have the Contract Number & Drawing Number detailed to the approval of the Engineer. Computer files containing Auto CAD Drawings shall be maintained as seamless Drawings.
- E. No final payment shall be made except for work that has been completed in accordance with the Specification and has been duly presented on the "As-Built" Record Documentation. The Contractor shall not be entitled to any extra payment or extension of time for the preparation or changes thereto of the As-Built Record Documentation.

Section 01310

PS 1.17 Progress Schedules

To enable the Engineer to interface with the scheduling system, the Contractor shall provide to the Engineer an original, licensed copy of the software used by the Contractor for scheduling purposes registered in the name of Ministry of Environment and Energy. This software shall be handed over to Ministry of Environment and Energy at the end of the project and will become the property of Ministry of Environment and Energy thereafter.

Section 01380

PS 1.18 Photography Requirements

- A. Prior to beginning of construction, initial photographs shall be taken at every bend, junction, culvert, bridge and every building adjacent to the site and at no more than 0.5 km apart along road and pipeline routes to record the existing conditions prior to construction.
- B. A minimum of Fifteen (02 sets) photographs shall be taken by the Contractor each month to record the progress of the Works. Photographs shall be standard postcard size, in colour, and shall be marked with date of exposure, and location. Where conventional photography is used, the negatives shall be supplied to the Engineer. High resolution digital photographs (minimum 20.3MP pixel format) will be acceptable, in which case a hard copy (CDRW disc or (equal) shall be supplied in lieu of negatives.

Section 01400

PS 1.19 Quality Control

- A. The measuring and test equipment provided by the Contractor shall be available for the use of the Engineer as required. The Contractor shall provide all necessary assistance and attendance to the Engineer for this use.

Section 01450

PS 1.20 Health and Safety

- A. The Contractor shall be responsible for the implementation of all safety related site procedures. These shall include working within, or about, cofferdams within rivers or other areas subject to flooding, including, but not limited to life saving buoys, life jackets, warning signs, barriers, diving apparatus and rescue craft.
- B. The Contractor shall erect the safety sign board adjacent to the main site office and also at the service reservoir, water tower and pumping station sites.
- C. The use of the words 'sewers' and/or 'sanitary structures' shall mean the same as 'enclosed spaces' and/or 'non-ventilated enclosures'.
- D. 'Workforce' shall mean in this case, only those personnel working within enclosed spaces or non-ventilated enclosures.
- E. The Contractor need not have test for radio-activity unless equipment specific safety instructions call for such tests.
- F. The Contractor need not provide a mobile mess room for each working area, but shall provide the emergency equipment nearby each working area.

Section 01500

1.21 Provision of office and other related facilities for the Engineer's Staff

1.21.1 Main Office

The Contractor shall provide for the exclusive use of the Engineer's Representative and his staff an office, as specified below within a central location of the sites to the approval of Engineer.

The office shall have minimum three rooms with a total floor area of at least 100 square metres. The office shall have overhanging eaves and be provided with windows with lockable shutters for security. A covered parking space for four vehicles should be provided

The doors should be of substantial construction and shall be fitted with a mortice lock. At least two keys shall be provided for each lock and the Contractor shall hand over all keys to the Engineer's Representative. The total floor area of office shall be air conditioned and provided with a wash basin with cold running water and 2 standing fans. The Contractor shall provide and maintain telephone / fax (with a broadband internet connection), electricity, toilet facilities (min 2), potable drinking water facilities, security and the following furniture and equipment to the office and all ancillary items to permit the efficient functioning of the office.

No.	Item	Required No
1.	Table 0.9m x 1.5m with four lockable drawers	02
2.	Table 0.9m x 1.2m with one lockable drawer	5
3.	Chairs	5
4.	Chairs with arm rest	5
5.	Lockable four drawer steel filing cupboard	5
6.	Set of shelving 1.2m high by 0.9m long with shelves for keeping the drawings, box files etc.	5
7.	Domestic water dispenser / filter	02
8.	Drawing stands to read A1 size drawings	02
9	Desk Top Computers with required software & UPS (Processor i7, Clock speed 3.8 GHz, RAM 64GB, HDD 1.5TB) With Networking software/hardware	03
10	Lap Top computers with required Softwares(17.3" Touchscreen, 6th Gen i7 Processor, 16GB RAM, 1TB HDD)	02
11	Laser Printers (with bluetooth, network facilities) A3 size	02
12	A3 Photocopy machine (ADF, Sorter, Network facility)	03
13	Fax machine	02
14	Digital camera (min 20.3 MP +64GB memory) with standard accessories, carry case	02
15	Helmets, Umbrellas, Raincoats, Calculators, Life jackets	Required quantities for all engineer's staff

All necessary facilities & equipment such as stationeries, consumables, office utilities, calculators and other miscellaneous office equipment shall also be provided by the contractor at his own cost.

The Contractor shall maintain the building and facilities, fittings and equipment in good condition, by a dedicated office assistant and provide all proper attendance and clear away on completion of the Contract, as directed by the Engineer. Equipment and furnishing of the office shall be handed over to the Employer upon completion of contract. Software (Genuine multi user) for the computers shall be MS Office, Autocad (2016), Virus Guard(Kaspersky). The contractor shall provide safe drinking water (bottled water in case of acceptable quality water is not available in the area) and milk / tea / sugar for the Engineer/Employer's staff.

1.21.2 Mobile Field Offices

The Contractor shall provide and maintain mobile type field office/s for the use exclusively of the Engineer's staff in numbers stated in the BOQ. The mobile offices shall be established at the sites as directed by the Engineer. These shall be maintained by the Contractor until the completion of construction works.

The mobile offices shall be provided with sufficient ventilation, weather proofed, insulated and painted internally and externally. Floor to ceiling height shall be at least 2.7 meters with minimum floor area 25m². The office shall have external lockable doors and windows as necessary. The office shall be well lighted and ventilated.

All office and the equipment and furnishings installed therein shall be provided and well maintained during the above period by the Contractor and equipment handed over to Employer upon completion of contract . All necessary facilities & equipment such as stationeries, consumables, office utilities and other miscellaneous office equipment shall also be provided by the contractor at his own cost.

The contractor shall provide janitorial services to maintain a good working environment and security at each office. Water Supply, electricity supply, tea for the staff and sanitation facilities shall be provided and maintained throughout the contract period.

Each Mobile Office shall be supplied with the following new furniture, equipment and services:

Item	Quantity
Steel tables 1.2m x 0.75m with two lockable drawers	3
Steel four drawer lockable filing cupboard	2
Arm chairs	5
Drawing / file rack (to keep A3 size drawings and box files, folders)	1
Water filter / Dispenser	1
Electric Fans (standing)	2
File Trays	4
Cutlery & Crockery	as necessary
Electric kettle	01
Leveling instrument (automatic) with staff and accessories	1
Desk Top Computers with required software & UPS (Processor i7, Clock speed 3.8 GHz, RAM 64GB, HDD 1.5TB) With Networking software/hardware	1

1.21.3 Transport for the Engineer's staff

The Contractor shall supply transport to of the Engineer's staff Between Male and Horafushi and within the Horafushi Island As instructed by Engineer.

Section 01570

PS 1.22 Traffic Control

- A. The Contractor shall obtain all necessary approvals from the appropriate authority having jurisdiction over the road, traffic police, and the Engineer for, and prior to implementation of, all traffic control operations.
- B. The Contractor shall take all necessary precautions and provide all necessary traffic diversions including watching, lighting, temporary barriers, temporary signals etc., all to the approval of the Engineer and the relevant authorities at no additional cost to Ministry of Environment and Energy.
- C. Payment for traffic control will be made as per relevant items provided in the B.O.Q.

Section 01580

PS 1.23 Project Signs

The Contractor shall provide, erect and maintain Project Signboards at locations directed by the Engineer. The Contractor shall submit designs for the Engineer's consent with the following minimum characteristics:

face plate size not less than 2.5 meters by 2.0 meters, double post supports with concrete foundations, colour messages and logos to include project name, name of the Employer, name of the Contractor, name of the Engineer, name of the government agencies, and the anticipated completion date.

The Contractor shall remove all signboards on completion of the Contract Period. The Contractor shall provide and install plaques made of brass or granite or other material with messages and logos approved by the Engineer at sites decided by the Engineer.

Project Signboards shall be measured as the number of signboards satisfactorily provided, installed, maintained throughout the Contract period and removed after completion of works. Project plaques shall be measured as the number of plaques satisfactorily provided, installed, maintained throughout the Contract period.

Payment shall be made at the stated unit rate per signboard/plaque. The price shall be full compensation for all resources required to perform the work described.

Section 01600

PS – 1.24 Materials and Equipment

- A. All products shall be imported in the name of Ministry of Environment and Energy and originals of all test certificates including the guarantees and warranties with Ministry of Environment and Energy named as the beneficiary shall be submitted to the Engineer at the time of delivery of all such products to site.
- B. The tests carried out by the Engineer are intended solely to check on the acceptability of materials and work completed. If the Contractor requires additional or more frequent testing to be undertaken to reduce the risk of his work being rejected by the Engineer, then this shall be carried out as the Contractor deems necessary.

PS – 1.26 Start-up, Performance Testing, Tests on Completion and Commissioning

- A. The issuance of the Taking Over Certificate requires that all operational, field and performance tests have been satisfactorily completed and all final test reports, after successful completion of the tests, have been delivered to, and accepted by, the Employer.
- B. Until the issuance of the Taking Over Certificate the Contractor shall be responsible for the supply and costs of power and all operating fluids and all other items necessary for the testing and operation of the facilities.

Section 02060

PS 2.01 Demolition

The Contractor shall demolish all structures as and when directed by the Engineer and as detailed on the drawings.

Section 02200

PS 2.02 Earthworks and Site Preparation

- A. In addition to the requirements of Clause 1.14 of Section 02200, the Contractor shall undertake a survey of all the underground existing utilities/obstructions/culvert foundations along all pipeline routes and shall determine the exact locations and depths of all such underground utilities and obstructions. The results of the survey shall be incorporated in the "As-Built" drawings.
- B. For each trial hole, the Contractor shall furnish a written report and a neat sketch of the data uncovered including:
 - 1. soil characteristics;
 - 2. utilities uncovered, materials, sizes and dimensions and depths;
 - 3. any other interesting observations.
- C. After the site clearance, the ground shall be excavated to form the finished compound level as shown on the drawings. All cut and fill slopes not likely to be disturbed by the construction of structures/buildings shall be trimmed to final profiles as indicated or as directed by the Engineer and close turfed immediately after trimming to prevent surface erosion. All turfing that has become defective within the construction period and the defects liability period shall be replaced at the Contractor's expense.
- D. For the erection of the outer fences the Contractor shall clear all trees and bushes in a 2 m wide, security strip on the inside of the fence. This strip shall be close turfed immediately after clearing to prevent surface erosion. All turfing that has become defective within the construction period and the defects liability period shall be replaced at the Contractor's expense.

Section 02221

PS 2.03 Trench Excavation

- A. The Contractor shall take all precaution's necessary to avoid damage to existing trees. Tree roots encountered larger than 75 mm in diameter shall not be cut and hand excavation may be required to avoid root damage.
- B. The Contractor is advised that the trench excavation will be adjacent to existing properties in numerous areas. Therefore all trenches shall be shored and braced, or

otherwise stabilized, to prevent damage to such properties, to prevent sloughing and to protect workman in the trench and to safely accommodate surface surcharge loads from excavated materials, pipe, equipment and vehicles. Design calculations and details by a certified soils engineer shall be submitted for approval prior to any trench excavation.

- C. The trench width may be increased at joints to allow proper installation of the joint. This increased working width should be kept to a minimum and shall be approved by the Engineer.
- D. Where the Contractor is required to carry out permanent reinstatement, the work shall be carried out in full compliance with the requirements of the relevant authority.
- E. All temporary and permanent reinstatements are deemed to be entirely covered by the Contractor's rates for pipeline installation unless separate items are provided in the BOQ..
- F. All temporary and permanent reinstatement restoration of surface water drains, culverts parapet wall, retaining wall, guard stones, access roads, private properties and other facilities are deemed to be entirely covered and priced in items provided in the BOQ. Any work to be included in this item in the opening of the bidder shall be incorporated. Bidders are expected to unit the rates before pricing. Digital photographs shall be taken and submitted along with the bid.

Prior to the commencement of pipe laying as far as practicable, Engineer shall nominate a soil testing laboratory and inspected the pipeline trace jointly with the Contractor to decide on the suitability of the materials to be excavated for backfilling of the trenches.

Engineer along with the soil laboratory personnel will decide on the locations where the soil tests are to be carried out to determine the soil parameters set out in Clause 2(v) and details given in the drawing Nos. Horafushi/STD/01, Horafushi/STD/02, Horafushi/STD/03 and decide on the suitability of the excavated material for backfilling based on the test results and recommendations of the soil laboratory personnel.

If the excavated soil is found to be unsuitable, Engineer shall inform the Contractor of the sections of the pipeline trace to be backfilled with imported soil from the approved borrow pits.

PS 2.04 Pipe Bedding

All pipes shall be laid in granular bedding, except where otherwise stated or where concrete surround is to be provided. The granular bedding shall be provided with a geotextile surround when directed by the Engineer.

It should be ensured that the trench bed is leveled in conformity with the levels as indicated in the drawing. The pipe bedding material shall be well graded and free from organic matter. Excavated material also could be used if it satisfies the requirements laid down in the drawing and with the approval of the Engineer.

The Contractor shall adopt the special bedding type A,B, C and D specified in the relevant type drawing where appropriate. When ground conditions requiring the use of special bedding types are encountered, the Contractor shall inform the Engineer, and with his approval, adopt the proper bedding type. The chainages indicate in the LS drawings for special bedding types, are only for guidance. Decision of the Engineer in this regard shall be final.

The filling material shall be the soil having the maximum dry density under standard conditions of compaction not less than 1600 Kg/m³ with the properties PL<15 , LL<40 , CBR >20 and the particle sizes not greater than 25mm.

The bedding material shall be Quarry dust, Mined sand or Crushed stone as specified in the relevant type drawing. When sand is used as bedding material, 100mm wide RCC grade 20 barriers at 50m intervals across the trench to cover full widths of the trench and full depth of the bedding shall be provided.

The trench shall have special protection when the soil condition is unfavorable in such a way the bearing capacity is less than 75 KN/m². The Geotextiles shall be used to bear the soil load above where it is specified in the type drawing Nos. Horafushi/STD/03 or directed by the Engineer. The Table 2 given below shall be referred for the properties of Geotextiles.

The Geotextiles shall be wholly synthetic and is tropic fibrous material. It shall have properties not inferior to those listed in Table 2.

Property	Test Method	Value	Unit
Tensile strength (wet and dry) under uniform applied stress		7500	N/m ²
Grab tensile strength	ASTM 1682 100m	660	N
Trapezoidal tear strength	ASTM 117	300	N
CBR Puncture resistance	DIN 54307E	1600	N
Burst Strength	ASTM 3786	1400	KPA
Pore Size		> 0.03 < 0.10	mm mm
Permeability to water under 100mm head		50	l/m ² /sec

When the minimum specified cover to the pipe line from the surface cannot be maintained due to some special reason, the Contractor shall adopt the special protection type using concrete pre-cast slabs as specified in the relevant type drawing and as instructed by the Engineer.

PS 2.05 Watercourse Crossings

- A. The Contractor shall furnish all labour, equipment and materials and perform all incidental work required to install watercourse crossings as shown, specified or directed by the Engineer.
- B. The Contractor shall submit for approval his proposed method and details of the construction. Approval of such methods and details shall not relieve the Contractor of his obligations.

- C. The Contractor shall take extreme care to protect the existing structures from damage. Vehicular and pedestrian traffic shall be maintained at all times. Costs or charges resulting from damage thereto shall be borne by the Contractor.
- D. Where crossings are outside of culverts but under the invert level, the necessary trench cut off walls and riprap shall be provided as shown on the Drawings.
- E. Steel used for pipe supports and incidental works of crossings shall be of structural steel as specified in Section 05120.

PS 2.06 Existing Services

The Engineer will assist the Contractor to collect drawings and data of existing utilities as supplied by the relevant authorities. The Engineer shall not be responsible for any inaccuracies, or incomplete information, on these drawings, and it shall be the Contractor's responsibility to check the accuracy of the same.

Temporary and Permanent reinstatement of roads shall be carried out by the Contractor in conformity with the specification as given in the Appendix to these Particular Specifications.

Section 02222

PS 2.07 Structure Excavation and Backfill

Where the formation of any excavation, being other than rock, is to support the foundations or floor of a structure, the bottom 150 mm of which shall be carefully excavated and trimmed immediately before placing the permanent work upon it.

Section 02520

PS 2.08 Roads

- A. The roads include the access roads to the service reservoirs, water towers , pumping station sites and some pipeline routes.
- B. Road construction shall be generally as detailed in the Technical Specifications but to the specific details as shown on the drawings. If any conflict occurs, then the details on the drawings shall take precedence.
- C. The wearing surface shall be laid at the end of construction period of the Contract and immediately prior to the issuance of the taking Over Certificate, as agreed by the Engineer.
- D. Road construction materials shall be selected in conformity with Standard Specifications for Construction and Maintenance of Roads and Bridges (SSCM) if any difficulty occurs in the selection of materials conforming to Clause 2.05 of standard specification (Vol 2B).

Section 02700

PS 2.09 Pipes

- A. The minimum cover to the top of the pipelines shall be 0.9 m.
- B. Ductile iron pipe buried in aggressive soil shall be installed in polythene sleeving. The fittings must be manufactured by the same manufacturer as the pipes, and the manufacturer must have an accredited local agent with technical support services. Any welding of ductile iron pipe and fittings outside of the pipe manufacturer's manufacturing facility will only be approved in exceptional circumstances, under strict quality control requirements and with the agreement of the pipe manufacturer. Where detailed, thrust blocks will be constructed on the pipelines to resist horizontal or vertical forces. The Contractor shall submit, for the Engineer's approval, details of his proposed location and types of required thrust blocks.
- C. The Contractor shall note that many of the routes of the pipelines are in narrow and winding roads. Therefore, the Contractor shall purchase a majority of the pipes in lengths not exceeding 6 m to assist in the laying of the pipes. Longer lengths of pipes may cause difficulties in transportation and laying.
- D. Flanges for all pipes, valves and fittings shall be PN 10, 16, and 25 as shown in the Drawings.
- E. The test pressure will be the one and half times the working pressure or rated pressure of the pipes, whichever is less.
- F. After testing the pipelines shall be flushed out with clean water and disinfection of the pipeline will be carried out.
- G. **Test Certificates**
Each consignment of pipes, pipe specials, fittings and valves delivered to site shall be accompanied with a witness testing and inspection certificate from a third party inspection and testing agency approved by the Engineer. The Engineer or his representative reserves the right to inspect the pipes, specials, fittings and valves to be supplied for the Works at the place of manufacture and to witness the manufacture and works tests. All cost for the witness tests shall be borne by the contractor and to be included in pipes supply rates
- H. **Transportation of Pipes & Fittings**
Any vehicle on which pipes, are transported shall have a bed of such length that the pipes do not overhang. Large pipes shall be placed on cradles and the loads adequately secured during transit. The pipes shall be handled in accordance with the manufacturer's recommendations.
- I. **Inspection of Pipeline Materials**
Transportation of pipes, specials, fittings and valves to site over rough terrain may give rise to a high proportion arriving damaged. Before incorporation into the pipeline each item of pipeline material shall be brushed out and carefully examined for soundness.

Damaged items which in the opinion of the Engineer cannot be satisfactorily repaired at site shall be rejected and removed from site. If under line test, the Engineer considers that an unacceptable proportion of the pipes within a test length has failed, the Contractor shall be required to test hydraulically to the works test pressure each pipe and joint before pipe laying. In this event, test results shall be submitted to and approved by the Engineer before any further pipes are laid.

J. Resistivity Survey

The Contractor shall undertake a resistivity survey along the route of the transmission main in accordance with the requirements of BS. 1377 Part 9, Section 5.1 to determine highly aggressive soil conditions and the type of special external coating system required. The results of the resistivity survey shall be presented in a tabular report format to be approved by the Engineer and the resistivity survey report for each section of pipeline shall be presented to the Engineer prior to placing the orders for pipes & fittings. As a minimum, the report shall list the following information for each measurement:

1. Date & time
2. National grid coordinates
3. Brief description of location
4. Resistivity values at depths of 1.5, 2, 3, 4 & 5m.

K. Pipeline Marker Tape

All pipelines shall be marked with an acid and alkali resistant polyethylene detectable warning tape with a minimum width of 300 mm for pipes more than 400 mm diameter or equal and minimum width of 150 mm for pipes for diameter less than 400 mm and shall consist of all accessories necessary for installation at the chambers, splicing, junctions etc. The tape shall be blue in colour and clearly marked in black lettering with "CAUTION – WATER MAINS BELOW" in both English & Sinhala/Tamil with a maximum repeat distance of not more than 1 m. The tape shall be placed during backfilling of the pipeline trench at a depth below finished ground level indicated on the drawings. The tape shall have a minimum strength of 125 kg/sq. cm in the longitudinal direction and 105 kg/sq. cm transversely. The minimum thickness of the tape shall be not less than 0.575 mm comprising of polyethylene sealing layer of 0.1 mm, aluminium foil of 0.075 mm and base layer of polyethylene 0.4 mm. The metallic conductor(s) shall be either aluminium foil having a width of not less than 50 mm and a thickness of not less than 0.075 mm or stainless steel wires. The foil/wires shall be totally enclosed within the polyethylene laminate such that the edges of the foil are totally protected against corrosive attack. The aluminium foil/wires shall be detectable from the ground surface using a buried cable locator. The manufacturer of the tape shall provide methods for joining and terminating the tape to enable a low resistance connection to be made to the foil/wires. Electrical connection points shall be made at each chamber along the pipeline route. Tape is not required in the reservoir sites. The cost of these identification marker tapes shall be included in the pipe line rates.

L. Casting Pipes into Concrete Sections

1. The Contractor shall provide and fix all ductile iron pipework both inside and immediately outside the structures as shown on the drawings. The pipework includes items required for building-in or under the structures. It is imperative therefore that the Contractor should place orders for these pipework items

immediately after the Contract is awarded and makes every effort possible to ensure early delivery to site.

2. The supply and delivery of the built-in pipework should be clearly shown on the construction schedule to be submitted by the Contractor in accordance with Section 01310 Para 1.02 of the Specification
3. Where specified all pipes passing through concrete in structures where a thrust load has to be transmitted to the structure shall be provided with a puddle/thrust flange and shall be fixed in position before and rigidly held in position during concreting. The supports shall not be removed until the concrete has set sufficiently to support the item. Boxing out of the opening in the above circumstances shall not be permitted.

M. Flotation of Pipework

The Contractor shall be solely responsible for ensuring that flotation of pipework does not occur during construction.

N. Pipeline Swabbing

Upon completion of water pipeline installation but before hydraulic testing, the Contractor shall demonstrate and prove that the line is clear of debris and obstructions. This will require a video camera survey of the pipeline.

O. Steel Pipes and Fittings

1. General

Where specified in the drawings, pipes and fittings to be used in the pump house/room shall be of mild steel conforming to the requirements specified in this section.

2. Standard Specification References

The following standards are referred to:

BS 4504	Circular Flanges for Pipes, Valves, and Fittings
AWWA CI04	Cement Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings
AWWA C200	Steel Water Pipe 6 Inches and Larger
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied
AWWA C205	Cement-Mortar Lining for Steel Water Pipeline
AWWA C208	Dimensions for Steel Water Pipe Fittings
AWWA C210	Coal-Tar Epoxy Coating System for the Interior and Exterior of Steel Water Pipe
AWWA C602	Cement Mortar Lining of Water Pipelines 4 inch (100 mm) and larger-In Place
AWWA Manual	Steel Pipe Design and Installation M11
ASTM A185	Welded Steel Wire Fabric for Concrete Reinforcement
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality
ASTM 307	Carbon Steel Externally Threaded Standard Fasteners
ASTM A570	Hot-rolled Carbon Steel Sheet and Strip, Structural Quality

BS 534	Flanges and Bolting for Pipes, Valves and Fittings
JIS G3101	Rolled Steel for General Structures
JIS G3443	Coated Steel Pipes for Water Service
JIS G3451	Fittings of Coating Steel Pipe for Water Service
JIS G3452	Carbon Steel Pipes for Ordinary Piping
JIS G3457	Arc Welded Carbon Steel Pipes
JWWA A109	Mortar-Lining of Steel Pipes for Water Works

3. Materials

(a) Pipes and Fittings

Steel pipe and fittings shall conform to AWWA C200 or equivalent standards, subject to the exceptions and supplemental requirements contained in the following sections.

(b) Steel Cylinder

For pipe and fittings, cylinder shall be fabricated from hot-rolled carbon steel sheets or plates conforming to either ASTM A283 Grade D, or ASTM A570 Grade 33, or JIS G3101 Class 2 SS 400. The minimum yield point of steel used for fabrication of steel pipe and fittings shall not be less than 2,300 kg/sq.cm. Steel conforming to JIS G3457 is also acceptable.

Fabrication of steel pipe and fittings shall be in accordance with AWWA C200 or BS534. The weld shall be of reasonably uniform width and height for the entire length of the pipe and shall be made by automatic means.

All longitudinal seams or spiral seams and shop girth seams of pipe shall be butt welded. The maximum allowable number of shop seams shall be one longitudinal seam and five girth seams per length of pipe. The longitudinal shall be staggered on opposite sides for adjacent section. No reinforcing ring, plate or saddle shall be provided on the exterior or interior of pipe.

All steel fittings except bends having a deflection angle less than 5 degrees shall be shop fabricated. Bends having a deflection angle less than 5 degrees may be field fabricated from shop fabricated steel pipe by means of field cutting and welding.

The pipe diameters shown on the drawings shall be of the nominal diameters.

(c) Fitting Dimensions

All fittings shall be of the same strength, outside diameter and wall thickness as that of pipes, and shall be provided with reinforcing rings and saddles when required in accordance with AWWA Manual M11 to meet the specially high pressure.

The dimensions of fittings shall conform to either JIS G3451 or AWWA C208 or equivalent.

(d) Joints and Pipe Ends

Pipes and fittings to be jointed by flexible coupling shall have the plain end.

Where shown on the drawings, flanged joints shall be provided. Flanges shall be made as seamless forgings or cut and fabricated from steel plates and shall conform to BS4504. Class of flange shall be PN10 unless otherwise specified on the drawings.

Material for flanges, bolts and nuts shall be the same steel used for fabrication of steel pipes and fittings. Flanges shall be steel welding neck flanges, and shall be attached to pipes or fittings by means of single butt-weld. All flanges shall be flat faced with bolt holes straddling the vertical axis of the pipes or fittings, and all gaskets shall be of at least 3.0 mm thick asbestos or neoprene, full face with bolt holes correctly sized and spaced. Flanges shall be supplied complete with the required size, quantity and quality bolts, nuts and gaskets.

(e) Lining

Steel pipes and fittings shall be lined internally at the pipe manufacturer's works with two coats of bituminous epoxy enamel conforming to AWWA C210 or JWWA K135-1989 with the total uniform dry film thickness of at least 300 microns (0.3 mm).

Fittings larger than 600 mm in diameter shall be wire-fabric reinforced. The wire-fabric shall be 2 x 4 steel wire mesh, 13 gauge each way, and shall conform to the requirements of ASTM A185.

(f) Coating

The exterior of pipes and fittings shall be coated with non-breeding type coal tar epoxy at the total uniform dry film thickness of at least 200 microns.

(g) Lining and Coating at Pipe Ends

At all pipe and fitting ends, coating and lining shall be extended to the pipe ends.

(h) Manufacturer's Mark

Each pipe and fitting shall bear the mark of the manufacturer; the nominal diameter; wall thickness; year of manufacturer; the wordings "Steel Pipe" or "SP", and the owner's name "Ministry of Environment and Energy". The marking shall be conspicuously painted in non-toxic paint on the outside of each pipe and each fitting.

4. Shop Testing

(a) Pipe

Shop testing and inspection of the pipe shall be conducted in accordance with AWWA C200 in the presence of the representative of the Engineer. The minimum hydrostatic test pressure for straight pipe shall be determined in accordance with Section 3.4 of AWWA C200 using the design stress equal to 75 percent of the minimum yield point of the steel used. When approved by the Engineer, the hydrostatic test may be replaced by other appropriate non-destructive testing methods such as ultrasonic and/or radiographic testing methods.

During pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Pipes that show any leakage under test shall be rewelded at the points of leakage and subjected to further hydrostatic tests until satisfactory results are obtained. All cost for the tests shall be borne by the contractor and to be included in pipes supply rates.

(b) Fittings

Upon completion of welding, but before lining and coating, each fitting shall be bulk headed and tested under the same hydrostatic pressure as for the pipe. Provided, however, that if fittings are fabricated from previously tested straight pipe, only those welding seams that were not previously tested in the straight pipe may be tested by means of ultrasonic or radiography method or other methods as approved by the Engineer, with no further hydrostatic test.

Any leakage and porous welds which may be revealed by the test shall be chipped out and re-welded and the fitting be retested until satisfactory results are obtained.

5. Mechanical Couplings and Flange Adapters

Couplings for jointing plain-ended pieces shall be of the Dresser Viking Johnson or similar type approved by the Engineer and may be steel or ductile iron at the option of the Contractor.

The middle ring (sleeve) and the follower rings (flanges) shall be of such materials and dimensions and that they are not stressed beyond half the yield stress of the material when the pipes connected by them are subjected to the stated hydraulic test pressure.

Except where otherwise stated, the middle ring (sleeve) of the coupling shall be provided with a suitable pipe stop (centre register).

The joint rings used shall be of Class 'A' natural rubber and the physical properties of the mix shall meet the requirements of BS 2494.

Flange adapters for jointing flanged specials to plain-ended pipes shall conform to the foregoing contents of this clause.

Prior to the commencement of the manufacture the Contractor shall submit to the Engineer for approval detailed drawings of all mechanical couplings and flange adapters.

All couplings shall be supplied with a shop coat of quick drying primer approved by the Engineer which is compatible with the materials to be subsequently used for moulding or painting.

When harness is specified with coupling or flange adapter, the harnessing shall be provided as recommended by the manufacturer of couplings or flange adapters. Harness joint shall be designed to withstand for the pull-out force caused by the internal pressure of 10 bar at the joint.

Section 03300

PS 3.01 Cast-in-place Concrete

A. All cast-in-place concrete for water retaining and water excluding structures shall be grade 35. All chambers and structures on the pipelines shall be considered as water retaining structures. All concrete for buildings shall be grade 25.

B. Concrete Mix

Concrete Grade	Max. Size Agg. mm	Min. Cement Content kg/m ³	Max. Free Water/Cement Ratio	Cube Crushing at 28 days	
				Trial Mix N/mm ²	Works Test N/mm ²
25	20	315	0.5	35	25

C. Concreting Records

A written record of the concrete works shall be made each day by the Contractor and kept available for inspection by the Engineer. The record shall contain the following:

1. the names of the Contractor's engineers who are responsible for the different phases of the concrete work, and also the names of their assistants;
2. the temperatures of air, water, cement, aggregates and concrete, together with the air humidity and type of weather;
3. deliveries to Site of concrete materials (quantity, type & brand of cement etc.);
4. inspections carried out, tests performed, etc., and their results;
5. times of commencement and completion of different parts of the concrete works, and times of erection and striking formwork;
6. quantity of cement, fine and coarse aggregate, water and admixture used for each section of work and the number and kind of test samples taken on these ingredients.

D. Blinding Concrete

Immediately upon completion of excavation, all excavated surfaces shall be covered with blinding concrete to prevent deterioration of the formation and to form a clean working surface for the structure as specified in Clause 3.06 C. The layer of blinding concrete shall be placed on the underside of all footings, ground beams and ground slabs. The underside of the blinding concrete shall be provided with a vapour barrier separation layer as specified in Clauses 2.12 A and 3.06 D.

E. Immediately upon completion of excavation, all excavated surfaces upon which a structure is to be placed, shall be covered with blinding concrete to prevent deterioration of the formation and to form a clean working surface for the structure as specified in Clause 3.06 C. The layer of blinding concrete shall be placed on the underside of all footings, ground beams and ground slabs. The underside of the blinding concrete shall be provided with a vapour barrier separation layer as specified in Clauses 2.12 A and 3.06 D.

F. The concrete surface finish and tolerances of the sedimentation tank floors shall be either as specified in Section 03300 or to the requirements of the scraper manufacturer, whichever are the more stringent.

Section 03900

PS 3.02 Testing of Water Retaining Structures

All structures, excluding building superstructures, but including isolation valve chambers, washout boxes, air/vacuum chambers, access and sewer manholes, etc. are to be considered as watertight structures and are to be tested as specified.

Section 07100

PS 7.01 Waterproofing and Damp-proofing

- A. Notwithstanding maintenance requirements for the Works, the Contractor shall warrant the Employer with the assurance of a reputable local insurance company that roofs and tanks shall remain waterproof and damp-proof in respect of workmanship and materials for a period of 10 years calculated from the time that the works are certified as substantially complete. The form of guarantee offered by the specialist applicator shall be submitted for the Engineer's approval prior to commencement of waterproofing. This guarantee shall in no way indemnify the Contractor against the improper performance of the waterproofing system.
- B. It shall be the Contractor's responsibility to ensure that the specialist applicator takes note of the structure, including any movement joints, on which the waterproofing or damp proofing is to be applied. The laying of a water proofing system on a concrete or steel surface will be taken as signifying the acceptance of that surface, both in terms of surface quality, spacing and arrangement of movement joints, by the Contractor and his specialist applicator.
- C. Waterproofing systems shall dress up all pipes and other penetrations to a minimum height of 250 mm outside of the structure being waterproofed. The Contractor shall ensure that all penetrations of the structure shall be water proofed in a workmanlike manner and in accordance with the manufacturer's instructions and to the approval of the Engineer.
- D. Sharp corners shall be filled with screed or other fillets and waterproofing shall be laid with generous overlaps in accordance with the manufacturer's instructions. When water proofing is to be applied on exposed areas, its colour shall be approved by the Engineer.
- E. Where finishes such as concrete paving or tiles etc., are laid over waterproofing membranes laid on concrete floors, the floor shall be tested for water-tightness prior to laying of these tiles etc.
- F. Joints with abutting structures shall be carried out with appropriate materials as required.

- G. Damp-proof courses between block or brick walls and concrete ground beams or slabs shall be hessian based bitumen strip to BS 743, Type 5A as specified in BS 6398 to the same width as the block walls. The damp-proof course shall be bedded in cement mortar (1:4) with 150 mm end laps and full width at passings and angles.
- H. The external faces of all underground structures in direct contact with the ground shall be damp-proofed as specified in Clauses 2.03 and 3.03 with bituminous damp-proofing.

Section 09870

PS 9.03 Coating Systems for Ferrous Metals

All exposed piping, fittings, appurtenances and valves within valve chambers, vaults, boxes, etc. shall be coated with System B.

Section 15101

PS 15.02 Valves

- A. Flanges for all valves shall be PN 16 unless otherwise specified.
- B. All valves of one type shall be from one manufacturer, unless approved otherwise, in exceptional circumstances, by the Engineer. The valve manufacturer must have an accredited local agent with technical support services.
- C. The details of the valves are as given in the Technical Data Schedules

Specification For Reverse Osmosis Plant

6-B-1 Water Consumption Data:

Maximum product water requirement = 100 m³/day

Operation = 24 hrs/day

6-B-2 Reverse Osmosis Plant Design Capacity:

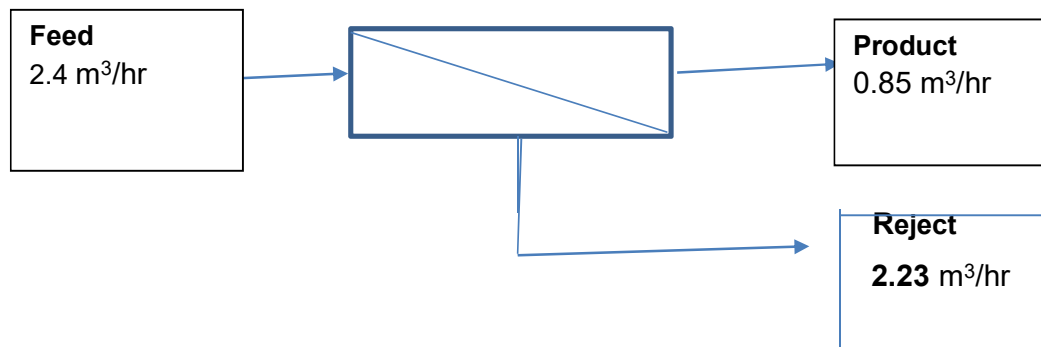
Operating hours = 18 hrs/day

Number of RO plants = 2 nos

Permeate (Product) flow rate per plant per hour = 0.85 m³/hr

Reject (Brine) flow rate per plant per hour = 2.2 m³/ hr

Overall recovery at each plant = 35%



A treatment plant consisting Dual media filtration, Anti scalant dosing, Micro filtration and RO membranes system is proposed with necessary pumps and storage facilities.

The water feed design temperature is one of the most important parameters and membrane manufacturers give the membrane nominal production based on defined and fixed test conditions. The defined test temperature is 25 °C.

Due to physical changes with temperature in some characteristics of the water, like viscosity, permeate flow or water production of a membrane could increase or decrease at a rate of 2.5% to 3% per degree of temperature, related to 25 °C (other

parameters remaining constant, i.e. salinity, pressure, pH and recovery ratio). By the temperature to be adopted in this design, the production should be guaranteed. The design temperature considered for this RO plant shall be 30 °C.

6-B-3 Treatment Processes/ Equipment

6-B-3 -1 FILTER FEED PUMP:

A centrifugal feed pump having 2.4 m³/hr discharge capacity should be installed to pump the raw water through the pre-filtration units and deliver the feed flow to the RO unit.

Quantity : One No (Duty)

Type : Centrifugal end suction

Bidder Has to Provide Following Data

Make :

Model :

Material of Construction :

Power :

Duty point :

Inlet/ outlet :

Raw water should be pumped to the RO pre-treatment system from borehole installed on site

6-B-3-2 MEDIA FILTRATION SYSTEM:

This filter should work in automatic mode, manufactured in GRP/ FRP, designed and tested at 10 bar_g pressure. The main characteristics of the media filtration system should be as

listed below:

No. of Filters : One (Duty) for each RO plant

Filtration flow : 2.4 m³ / hr

Media Filter size : 20 microns

Bidder has to Submit Following Data

Filter Diameter :

Filter Height

Make/ Model

Media : Gravel, Sand & Anthracite

Material of Construction : GRP/ FRP

Operation : Automatic

Graded sand should be available locally and product certificate for particle size distribution and uniformity shall be furnished by the contractor.

6-B-3-3. CARTRIDGE FILTERS:

The water pumped through the media filter shall be fed to the Cartridge filter. This filter should work in automatic mode, manufactured in GRP/ FRP, designed and tested at 10 bar_g pressure.

The main characteristics of the Cartridge filtration system should be as listed below:

No. of Filters : One (Duty) after each Media filter

Bidder Has to Submit Following Data

Filter Diameter :

Filter Height :

Make/ Model :

Media : Natural or synthetic yards, wound around central tube

Maximum Filtered particle size : 5 micron

Filters should be available locally and manufacturer's product certificate for particle size distribution, moisture, ash, pH, surface area and iodine adsorption number shall be furnished along with the bid.

6-B-3-4. CHEMICAL DOSING SYSTEM

The feed water must be chemically treated to avoid scaling on the surface of the membrane and to avoid oxidants attack over the membrane. The chemical pre-treatment will be composed of:

6-B-3-4.1. Antiscalant Dosing System

Quantity : One.

Accessories. : Injection valve, Foot valve, Tubing

Dosing Tank : One No, HDPE/GRP

Capacity : 500 l

Dosing pump : One No, Data

Bidder has to submit following

Make/ Model :

Antiscalant proposed :

Dosage : mg/l

Antiscalant quantity : kg/year

6-B-3-5 . HIGH PRESSURE PUMPING

The conditioned and filtered water comes to the HP pumping system, which pumps it to the RO membranes.

Bidder has to submit following Data

High pressure pump : One Nos per RO plant

Make :

Model :

Material of construction : All wetted parts SUS304

Power :

Duty point :

Inlet/ Outlet :

6-B-3-6. RO MODULE:

The single pass RO should produce 15 m³/day of permeate working 18 hours per day. These membranes should have a high chemical resistance in pH range from 2 to 12 which allows easy clearing and recovery because a wide variety of chemical products can be used. These membranes should be mounted into pressure vessels. The permeate water from each pressure vessel should be collected where water flow and quality are controlled. A valve for permeate sampling will be installed at the outlet of each vessel.

Rotameters shall be provided for permeate and reject streams. Low pressure switch to be provided on the suction side of the high pressure pump. The system should be protected against dry run. Inlet solenoid valve/ flush solenoid valve and pressure regulator shall be provided and Pressure gauges are necessary to identify all differential pressures across the treatment plant. Treated water on-line electrical conductivity (or TDS) meter shall be installed. Preference will be given for original membrane manufacturers submitting RO plant simulation with feed data, water balance, array data and chemical dosing data for the proposed design.

The original membrane manufacturer should be also available for fully fledged technical services during the bid negotiation, project implementation and also providing after sales services for this project.

RO original membrane manufacturers letter of authorization for the bid requirement should be submitted along with the bid.

Number of membranes :

Bidder Has to Submit Following Data

Make : Hydranautics/ Filmtec/ GE

Type :

Model :

Material of construction :

Number of pressure tubes :

Make :

Material of construction :

This process should possess a salt rejection rate of 97% – 99%. This system shall consist of MSEP/ SUS304 pe-fabricated skid for mounting of high-pressure tubes [pressure vessels] assembled with RO membrane elements. Basic desalination of feed takes place in RO skid. A PLC based control system shall be proposed for the total treatment system.

6-B-3-7. DISINFECTION:

Disinfection is done by chlorine dosing in a contact tank. Water from RO plant is fed to the contact tank and mixed with Sodium Hypochlorite of concentration 1 mg/L. The water should remain in the contact tank for 30 minutes before being pumped to Storage tanks. Chlorine should be added to contact tank using a chlorine dosing pump.

Bidder has to Submit Following Data

Number of pumps : 1 nos pump

Make :

Type :

Model :

6-B-3-8. RECIRCULATION / TRANSFER PUMP:

As product water is stored in the storage tank over a long period, to avoid stagnation, it is required to circulate water within the tank and also transfer water from one tank to another using a small recirculation pump.

Bidder has to Submit Following Data

Number of pumps : 1 nos pump

Make :

Type :

Model :

6-B-3-10. WATER SUPPLY PUMPS:

Product water is pumped to harbor kiosk using a centrifugal pump of capacity 1 kW.

Bidder has to Submit Following Data

Number of pumps : 1 nos pump

Make :

Type :

Model :

6-B-3-11. EQUIPMENT INSTRUMENTATION AND CONTROL

All instruments required to monitoring the below listed parameters should be installed and connected to the control system.

9.1. Rotameters:

9.2. Conductivity meter:

9.3 Flow switches:

9.4 Pressure regulator:

9.5 Solenoid valves:

9.6. Level switch/ controllers:

9.7. Flow control Valves:

9.8 Sampling valves:

9.9. Pressure gauges:

9.10. PROGRAMMABLE CONTROLLER (PLC)

9.11. RO Controller MIMIC panel

6-B-3-11. POWER SUPPLY:

230 VAC, 50 Hz, 3 ph

Control Panel : IP 55, MSPC

6-B-3-13. REJECT WATER DISCHARGE/ DISPOSAL:

The method of disposal of reject water shall be elaborated with attached drawings.