

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

**NATIONAL WATER SUPPLY AND DRAINAGE BOARD  
MINISTRY OF HOUSING AND PLANTATION INFRASTRUCTURE  
DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA**

**THE DETAILED DESIGN STUDY  
ON  
GREATER KANDY WATER SUPPLY  
AUGMENTATION PROJECT  
IN  
THE DEMOCRATIC SOCIALIST REPUBLIC  
OF  
SRI LANKA**

**FINAL REPORT**

**(DRAFT) TENDER DOCUMENTS**

**VOLUME 2B  
(STANDARD SPECIFICATIONS)**

**MAY 2002**

**NJS CONSULTANTS CO., LTD.  
NIHON SUIDO CONSULTANTS CO., LTD.**

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## **Contract GK/JBIC/04 Tender Documents**

The Tender Documents comprise the following volumes:

### **Volume 1**

- Invitation to Tender
- Check List of Submissions
- Instructions to Tenderers
  - Annex ITT 1- Outline of the Project
  - Annex ITT 2- Form of Tender Guarantee
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- Form of Tender
  - Appendix to Tender
- Form of Agreement
- Conditions of Contract
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  - Part 2 Conditions of Particular Application
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- Technical Schedules
- Functional Design Specification

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## 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

A The Particular Specifications and the Technical Specifications shall be read in conjunction with the other Contract Documents.

B The Technical Specifications are to provide overall guidance in the execution of the Works and shall apply except where contradicted by the Particular Specifications.

C 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.

D 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.

E 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.

F 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.

G 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.

H Workmanship will be accepted of only the highest standard.

I 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.

J 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 A soils investigation report is available as described in Section 02200. The report is indicative only of the conditions of various points within the Contract area. The Employer does not guarantee the accuracy of the data in the Report, nor does he guarantee it is typical of the ground conditions likely to be encountered. 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**

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## 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:
- 1 preparation of schedules,
  - 2 installation and removal of temporary facilities,
  - 3 delivery and processing of submittals,
  - 4 progress meetings,
  - 5 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 utilisation 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

- A 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.
- B 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.
- C 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.
- D 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.

- E 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.
- F 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 <sup>2</sup> , sq m	square metre
m <sup>3</sup> , cu m	cubic 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
ASAHC	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 (NPFA 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 manufacturer's 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 Pre-training Conference**

- A A meeting shall be held prior to beginning training and shall comply with requirements specified in Section 01670. The Contractor, training instructor, Engineer and his representatives, and plant operations staff shall attend.
- B 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 classroom and support requirements,
  - 2 training schedule,
  - 3 training plans,
  - 4 prerequisites,
  - 5 other items deemed necessary by the Engineer's Representative.

**1.08 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.

### **1.09 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.
- I The Contractor shall coordinate drawings and product data, and such coordination shall include:
  - 1 drawings and data previously submitted,
  - 2 drawings and data being prepared
  - 3 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.
- J 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.
- K 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.
- L The Contractor shall not perform any work until drawings or data have been submitted to, and approved by, the Engineer.
- M 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: \_\_\_\_\_ DATE: \_\_\_\_\_  
 \_\_\_\_\_  
 (Signature)

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:

- D - Shop Drawing
- 03300 - Specification for Concrete
- 008 - The eighth separate submittal under this section.
- B - The second submission of that particular information.

N 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.

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.

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.

O 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 Installation and Operation and Maintenance Manuals**

- A The Contractor shall submit manuals for all equipment, valves and components specified in the Technical Specifications and furnished by the Contractor.
- B The manuals shall be as specified in Section 01730 and the Contractor shall submit two copies of drafts for review. The Engineer will mark up one copy and return it to the contractor for correction and will retain one copy for project files.
- C The installation manuals shall be submitted at the same time as the draft operation and maintenance manuals.
- D The Contractor shall submit twelve copies of approved installation manuals incorporating all of the Engineer's comments and corrections prior to beginning installation of equipment.
- E The Contractor shall submit six copies of approved operation and maintenance manuals incorporating all of the Engineer's comments and corrections prior to completion of the work.

#### **1.08 Certificates and Affidavits**

- A 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.
- B 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.

#### **1.09 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 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

- A The Engineer shall be under no obligation to process the Contractor's payment application until the Contractor meets the requirements of this Section.
- B 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,
- C 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.
- B 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.
- C 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**

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:

- 1 name of project,
- 2 contract no.,
- 3 date,
- 4 orientation and description of view,
- 5 name and address of photographer,
- 6 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**

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## 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:
  - a items to be supplied by each supplier and sub-contractor,
  - b model or catalogue numbers,
  - c specifications,
  - d inspection and test requirements,
  - e performance data,
  - f anticipated inspection and test dates,
  - g 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.
- 6 document and submittal control procedures.
- 7 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.
- C The Contractor shall record equipment and material identifications and ensure that they are traceable to the location where they are incorporated into the work.
- D 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

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

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**

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## 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 paratyphoid 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,
  - 3 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 H<sub>2</sub>S),
  - 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**

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## 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. 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.

- B 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**

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**

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## **Section 01580**

### **Project Identification Signs**

#### **Part 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**

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## 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**

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## 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

- A “Component” means an individual item, piece of equipment, or equipment group as specified in a single section of these specifications.
- B “Startup Plan” means a single and complete plan incorporating all requirements of this Section.
- C “Subsystem” means a grouping or assembly of components, all of which operate together to produce the specified performance.
- D “System” means an assembly of subsystems and components.
- E “Validate” means to support, substantiate, and authenticate specified operation on a sound and authoritative basis.

##### 1.03 Quality Assurance

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**

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**

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**

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 01661**

### **Operational, Field and Performance Testing**

#### **Part 1 General**

##### **1.01 Description**

This Section includes operational, field and performance testing.

##### **1.02 Operational, Field and Performance Testing**

- A After all construction is complete and before acceptance, the Contractor shall perform operational, field and performance tests as called for in the Specifications. The Contractor shall demonstrate to the Engineer the operation of the facilities for proper sequence of operation and satisfactory performance of the system and individual components. Any improper operation of the system or any improper, neglected or faulty construction shall be repaired or corrected to the satisfaction of the Engineer. The Contractor shall make such changes, adjustments or replacement of equipment as may be required to make same comply with the specifications, or replace any defective parts or material.
- B At the time of testing, failure of the system to perform at the specified level will be the responsibility of the Contractor. In the event of failure of equipment to meet the specified performance, the Employer reserves the right to not accept such equipment or system, withhold funds due to the Contractor and/or make claims on the performance security.
- C The Contractor shall prepare and submit a consolidated schedule of operational, field and performance tests not later than three months before the scheduled start of the first test. The schedule shall be updated at monthly intervals. The Contractor shall prepare and submit weekly a schedule of tests to be carried out during the following week and shall inform the Engineer not later than twenty-four hours in advance of changes in the scheduling of a test.
- D For all specified performance tests, the Contractor shall prepare and submit:
  - 1 draft test procedures not later than two months in advance of the scheduled date,
  - 2 final test procedure not later than two months in advance of the scheduled date,
  - 3 test report within fourteen days of the successful completion of the test.

**End of Section 01661**

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## Section 01670

### Training

#### Part 1 General

##### 1.01 Description

This Section establishes the requirements for operation and maintenance training. 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. Training required by this Section is in addition to, and not a replacement for, manufacturer's equipment training required by the individual Technical Sections. The Employer reserves the right to video tape or otherwise record the instruction training presentations.

##### 1.02 Training Requirements

- A The Contractor shall develop individual training courses for each system identified on the Contract P & ID's. Three separate training sessions shall be provided for mechanical operations, mechanical maintenance, and electrical and instrumentation operation and maintenance. All manuals and presentations shall be presented, or conducted, in both the local and English languages.
- B The Contractor shall develop and submit the curriculum to the Engineer for approval based on the following:
  - 1 the curriculum shall be established for high school graduate level and shall include tests with at least 15 questions on each outline topic
  - 2 a task and skills analysis shall be performed, identifying the requirements for proper operation, maintenance, and repair of the system and all of its components.
  - 3 a training analysis shall be performed identifying: tasks requiring training; logical order of presentation; objectives of each training segment; and methods for measuring achievement of objectives for each segment.
- C An instructor's manual shall be prepared, including notes to the instructor, for each training session. The manual shall address:
  - 1 session objectives,
  - 2 session outline,
  - 3 session application,
  - 4 instructor qualification and knowledge requirements,
  - 5 list of tools and supplies required for instruction,
  - 6 safety and standby equipment,
  - 7 student and course evaluation forms,
  - 8 audio/visual resources or reproductions,
  - 9 session tests and a grading guide,
  - 10 references to the source of answers shall be provided in the course material,
  - 11 additional notes such as references, review questions, demonstration techniques, class exercises, coordination with other sessions, and achievement measurements.
- D Instruction shall be in accordance with the following:
  - 1 timing of sessions shall be to suit Employer's normal working hours.
  - 2 a 10 minute break shall be provided after each hour of instruction.
  - 3 the size of the class shall not exceed 15 people.

- E Minimum curriculum requirements shall be:
- 1 theory of operation and control shall include both classroom and “hands on” training,
  - 2 how to use the Operation and Maintenance Manual including the location of information,
  - 3 system layout,
  - 4 wiring, instrumentation and controls,
  - 5 control sequence and logic,
  - 6 normal and emergency operating procedures,
  - 7 basic and advanced operation and maintenance,
  - 8 equipment/instrument adjustment and calibration,
  - 9 site walk through to locate and identify equipment,
  - 10 preventive maintenance,
  - 11 major maintenance,
  - 12 safety,
  - 13 trouble shooting,
  - 14 how to use special tools,
  - 15 operation and maintenance supplies,
  - 16 spare parts.

### 1.03 Submittals

All submittals shall be as specified in Section 01300 and the following shall be submitted in both local and English languages for approval:

- 1 curriculum development document,
- 2 one copy of an instructor’s manual shall be provided for review. After acceptance (and before training) one copy and one camera-ready original shall be provided,
- 3 complete schedule of training activities including: schedule of submittals; schedule of classes; and coordinate with startup activities specified in Section 01650,
- 4 training plan including course outline; time allocation for each training segment and instructor qualifications,
- 5 presentation materials - two reproducible copies,
- 6 manuals and class handouts – one reproducible copy for review and one copy for each student at least five working days prior to class.

### 1.04 Quality Assurance

- A The minimum experience for the instructor shall be three years actually operating and maintaining equipment and he/she shall have academic or factory training with a combination of training and experience. The Employer reserves the right to reject instructors lacking experience and education required to conduct the training. The instructor’s qualifications shall be submitted for approval.
- B A pre-training conference shall be scheduled not less than seven calendar days prior to training. The Employer, Engineer, Contractor, training instructors, and other responsible parties shall attend. The Contractor shall submit an agenda five working days prior to the conference. The agenda shall include: training schedule; examination of training facilities; and problem identification and resolution.

### 1.05 Training Area

The training area shall be provided by the Contractor and the minimum requirements to be provided are:

- 1 air conditioned,
- 2 seating for 15 students,

- 3 tables suitable for students to write and lay out class materials,
- 4 all equipment required for audio/visual presentations.

### **1.06 Sequencing and Scheduling**

- A The Contractor shall conduct classroom training prior to system startup and conduct hands-on training prior to system demonstration tests.
- B The Contractor shall notify the Engineer at least three days in advance of scheduled training of any delays. Failure to provide required notice shall make Contractor responsible for costs incurred by the Employer for Employer's personnel. The Employer may delay scheduled training by up to five calendar days for personnel time conflicts but shall notify Contractor of delay at least three days in advance of scheduled training.

## **Part 2 Products**

### **2.01 Materials**

The Contractor shall provide; all materials and supplies (including consumables) necessary for training and demonstrations; special tools required for training and demonstrations; and all safety equipment required by instructors.

## **Part 3 Execution**

### **3.01 Preparation**

All required submittals must be approved prior to their use by the Contractor in delivering training courses. The Contractor shall assemble instruction materials and set up demonstration material prior to classes.

### **3.02 Training**

- A The Contractor shall provide not less than the days of training specified in the Particular Specifications.
- B The Contractor shall prepare a student evaluation for each attending student and present in a summary report. Originals of the student course evaluations shall be submitted to the Employer in the summary report.
- C The Contractor shall evaluate students' understanding of course material and shall conduct written tests at the end of each training segment. Tests shall be graded and evaluated to ensure fulfillment of course objectives. The original graded tests shall be submitted to the Employer.
- D Training methods, teaching techniques, and trainer qualifications will be evaluated by the Employer or his designated representative. Unacceptable training will be repeated at Contractor's cost.

**End of Section 01670**

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## 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

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

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**

- A 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.
- B 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 01730

### Operation and Maintenance Manuals

#### Part 1 General

##### 1.01 Description

This Section includes format and content of manuals and schedule of O&M Manual submittals.

##### 1.02 Submittals

Final O&M Manuals are required prior to Substantial Completion.

##### 1.03 Format

- A Manuals shall be prepared as instruction manuals and presented in commercial quality, three ring binders with hard plastic coated covers and maximum ring size shall be 75 mm. Manual contents shall be organized into numbered section titles and each section shall be separated by a tabbed fly sheet.
- B The Contract number and title of the “OPERATION AND MAINTENANCE MANUAL” shall be printed on the cover of each binder and list the contents of each binder on the cover.
- C All manuals shall be prepared in both the local and English languages.

##### 1.04 Manual Contents

- A All manuals shall comprise:
  - 1 cover sheet including project title, names, addresses and telephone numbers of the Employer, Engineer, Contractor and other responsible parties;
  - 2 table of contents;
  - 3 product data identifying specific products and component parts, product location and, where appropriate, supplement product data with drawings, manufacturers manuals and typed explanatory text;
  - 4 warranties and bonds.
- B Manuals for materials and finishes shall include:
  - 1 product data, with catalog number, size, composition, colour, and texture designations;
  - 2 provide information for re-ordering custom products;
  - 3 instructions for care and maintenance shall include:
    - a manufacturer’s recommended cleaning agents and methods;
    - b cleaning precautions (identify detrimental agents and cleaning methods);
    - c recommended cleaning and maintenance schedule.
  - 4 moisture protection and weather exposed products shall include:
    - a product data listing;
    - b applicable reference standards;
    - c chemical composition, and details of installation;
    - d inspections, maintenance, and repair recommendations;
  - 5 additional requirements and design data as specified in individual Specification sections.
- C Manuals for equipment and systems shall include for each equipment item and each system:

- 1 description of unit or system, and component parts;
- 2 state function, normal operating characteristics, and limiting conditions;
- 3 performance curves, with engineering data and tests;
- 4 details of manufacturers, recommended spares and maintenance task descriptions;
- 5 motor control centres single line diagrams, and wiring diagrams for circuits and sub circuits;
- 6 control descriptions as well as details of both controls and telemetry systems;
- 7 for panel board circuit directories electrical service characteristics, controls and communications shall be provided;
- 8 'as-installed' internal and external wiring diagrams;
- 9 operating procedures which shall include:
  - a start up and shut down procedures;
  - b routine operating instructions;
  - c emergency operating procedures;
  - d summer, winter, and any special operating instructions as appropriate.
- 10 maintenance requirements which shall include:
  - a trouble shooting procedures;
  - b disassembly, repair, and re-assembly instructions;
  - c alignment, adjusting, balancing, and checking instructions;
- 11 servicing and lubrication schedule including lists of recommended lubricants;
- 12 manufacturer's recommended operation and maintenance instructions;
- 13 complete description of all operating sequences;
- 14 original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance;
- 15 "as-installed" wiring diagrams by panel manufacturer;
- 16 Contractor's record drawings, with "As-installed" mechanical installation and process flow diagrams;
- 17 charts of valve tag numbers keyed to Contract Process and Instrumentation Drawings including the location and function of each valve;
- 18 lists of original manufacturer's supplied spare parts with latest (dated) prices;
- 19 test reports for dynamic balancing;
- 20 design data and other information as specified in individual Specifications sections.

**End of Section 01730**

## Section 02060

### Demolition

#### Part 1 General

##### 1.01 Description

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 with out 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**

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## 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

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

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**

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

- A 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.
- B 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.

- D 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**

- A 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.
- B The width of the excavation shall be increased, if necessary, to provide space for sheeting, bracing, shoring, and other supporting installations.
- C The Contractor shall furnish, place and subsequently remove such supporting installations unless ordered otherwise by the Engineer.
- D 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.
- E 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.
- F 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**

- A 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.
- B 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**

- A 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.

- B 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.
- C 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	min 2%
Acid Soluble Chloride Content	BS 1377 : Part 3 : Method 7	max 2%
Compaction Test	BS 1377 : Part 3 : 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

- 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.
- C 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 25 percent 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 warranty 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

- A 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



- 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**

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-leveling 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

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 m<sup>2</sup>, whichever is more stringent,
- 2 one test per backfill layer for every 100 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**

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**

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## Section 02221

### Trench Excavation and Backfill

#### Part 1 General

##### 1.01 Description

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 unplasticised polyvinylchloride (uPVC) 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

- A "Trench excavation" is as defined in Section 02200.
- B "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 (mm)	% Weight of Passing	
	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 SO<sub>3</sub>.
- 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 transmission pipe 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 (uPVC, GRP, HDPE etc.) the minimum trench widths for these pipelines depend on the deformation modulus of the bedding material ( $E_B$ ) and of the native soil ( $E_S$ ) at the springing or axis level of the pipe. The deformation modulus of the native soil ( $E_S$ ) 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  $E_B$  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  $E_B$  value is satisfactory, normal compaction procedures for granular bedding and surround shall be adopted. If the  $E_B$  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  $E_S$ , 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  $E_B$  and  $E_S$  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  $E_S$  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**

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**

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 uPVC 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, 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 an adequately thick layer of asphalt mix to provide a minimum consolidated thickness of 100 mm when well compacted by an 8000 kg power driven roller. The edges of the broken surface of existing paving shall be scarified and trimmed to straight lines before the smooth continuous surface matching the existing surface in level shall result.
  - 2 after scarifying and trimming the broken edges of the existing surface, a base of crusher run rock fill, or gravel, 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 100 mm when well compacted by a power driven 8000 kg roller. A tack coat of emulsified bitumen shall then be applied at a rate of 1 litre per 2 sq. metres and a layer of clean sand shall then be spread over the bitumen. The surface shall finally be rolled with an 8000 kg power driven roller to provide a surface that matches the level of the existing paved surface.
  - 3 as required by the concerned authority.
- 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**

The Contractor shall restore all non-asphalt road and all other surfaces to their original condition and this reinstatement is deemed to be entirely covered by the Contractor's rates for pipe installation.

### **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 backpacted 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

- A Definitions of terms are as defined in Section 02200.
- B 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.
- C 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:

<u>Sieve Size</u>	<u>% by Mass Passing</u>
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 Contractor 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**

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**

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## Section 02520

### Roadworks

#### 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:

- 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 <sup>2</sup>
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/mm<sup>2</sup>.
- 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 on 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/mm<sup>2</sup> and the strength of any individual block shall be not less than 40 N/mm<sup>2</sup>. 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 SO<sub>3</sub>) - 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.

<b>Sieve Size</b>	<b>% By Weight Passing</b>
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

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.

<b>Test</b>	<b>Standard</b>	<b>Limit</b>
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%
Ten Percent Fines Value	BS 812 : Part III	min 50 kN
Los Angeles Abrasion	ASTM C131/C535	max 30%
Soundness (MgSO <sub>4</sub> )	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%

- B 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.

<b>Sieve Size</b>	<b>% by Weight Passing</b>
50 mm	100
37.5 mm	70 -100

10 mm	40 - 70
5 mm	30 - 60
2.36 mm	20 - 50
0.425 mm	10 - 30
0.063	5 - 15

Material shall conform 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 (MgSO <sub>4</sub> )	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%

C 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:

- a material shall be retained on a 4.75 mm sieve,
- b consist of crushed rock or crushed gravel,
- c shall be clean, hard, tough, durable and sound,
- d shall be of uniform quality and free from decomposed stone, shale, clay, lumps and other deleterious substances,
- e 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,
- f 100 percent by weight of each stockpile shall have one crushed face,
- g at least 50 percent by weight of each separate stockpile of aggregate shall have all faces crushed,
- h 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 (MgSO <sub>4</sub> )	ASTM C88	max 10%	max 10%

Test	Standard	Base Course/ Binder Course	Wearing Course
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:

- a consist of the material passing a 4.75 mm sieve,
- b 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,
- c use of dune sand shall not be permitted,
- d fine aggregates shall have properties which comply with the following values:

Test	Standard	Limit
Soundness (MgSo <sub>4</sub> )	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

## 3 Filler material

- a 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,
- b consist of finely ground particles of limestone or cement in accordance with ASTM D242,
- c shall be thoroughly dry and free from organic substances and clay,
- d 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

- a shall be penetration grade 60 – 70,
- b bitumen shall be prepared by refining crude petroleum by suitable method,
- c shall be homogeneous and free from water,
- d shall not foam when heated to 175°C,
- e 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	-

Test	Method		Min	Max
	AASHTO	ASTM		
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

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

#### D Asphaltic Concrete

- 1 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

- 2 use of sand in mixes will not be permitted,
- 3 combined mineral aggregate shall meet the following requirements:
- 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
- 4 gradings given in the above Table represent the extreme limits which shall determined 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 the above table as appropriate,
  - 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,
  - wearing course shall be uniformly graded from coarse to fine.
- 5 coarse aggregate, shall show no detrimental amount of stripping when tested in accordance with ASTM D 1664,
- 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.
- 6 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,

7 no extra payment will be made for required anti-stripping additives,

8 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

E Dense Bitumen Macadam.

1 when tested according to ASTM C117 and ASTM C136 the mixes shall conform to the following grading:

a 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

b 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

- 2 use of dune sand in mixes will not be permitted.
- 3 combined mineral aggregate shall meet the following requirements:
  - a sand equivalent value (ASTM D2419) determined after all processing except for addition of asphalt binder min 65.
  - b plasticity Index BS 1377: Part 2: Test 5 Non-plastic
- 4 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,
- 5 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.
- 6 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.
- 7 no extra payment will be made for required anti-stripping additives.
- 8 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

F. Prime Coat.

- 1 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.
- 2 material
  - a medium curing cut back asphalt MC-70,
  - b 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
Residue from distillation to 360° C, % by	AASHTO T78	55	-

Test	Method	Limits	
		Min	Max
volume difference			
Tests on residue from distillation:			
Penetration at 25° C, 100g 5 sec.	AASHTO T49	120	250
Ductility at 25° C, cm	AASHTO T51	100	-
Solubility in trichloroethylene, %	AASHTO T44	99	-
Water content, % by volume	AASHTO T55	-	0.2

G Tack coat

- 1 bituminous tack coat shall consist of supplying and applying emulsified asphalt diluted with an equal quality of water (1:1) to a previously prepared:
  - a bituminous base course,
  - b binder course or,
  - c existing bituminous surface in accordance with this specifications,
- 2 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	-

- 3 sampling shall be in accordance with ASTM D140.

## 2.06 Traffic Markings

- A Thermoplastic materials shall conform to BS 3262 : 1989 : Part 1 except where modified in this Specification.
- B Ballotini shall be in accordance with BS 6088 : 1981.
- C 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:
  - 5
    - a aggregate 40 parts
    - b Ballotini 20 parts
    - c pigment and extender 20 parts
    - d binder 20 parts
- D 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.
- E 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.

- F 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.
- G 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.
- H 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.
- I 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.
- J 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.
- K 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; ½to 3½poises at 25° C viscosity. When heated for 16 hours at 150° C it shall not darken excessively.
- L Softening point of the binder shall be used only as a guide to quality control.
- M 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

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

2 grading of combined aggregate pigment and extender:

Sieve Size	By Weight Passing	
	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.

N Performance requirements

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

Property	Minimum	Minimum
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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	-

O 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  $23 \pm 2^\circ\text{C}$  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 alykyd 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 be 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 shade 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  $\pm 2$  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 m<sup>2</sup>, 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  $\pm 2$  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.

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.
- B 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.

- C 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 mix 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:
 
$$\text{VFB} = \frac{(\text{VMA} - \text{VIM})}{\text{VMA}} \times 100$$
  - 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
 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.

D. 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.

- E Heating of the bitumen binder for mixing and compacting shall be in accordance with ASTM D1559.
- F 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.
- G. 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  $\pm 8^\circ \text{C}$  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.
- H. 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.

I. 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:
 

	<b>Minimum</b>	<b>Maximum</b>
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.

J. 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:
  - a adequacy of the Contractor's equipment.
  - b loose depth measurements necessary to result in the specified compacted layer depths.
  - c field moisture content.
  - d relationship between the number of compaction passes and the resulting density of the material.
10. 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.

K. 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.

- 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.

M. 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.

N 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.
- O 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.
- P 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.
- Q Thickness of the bituminous paving courses shall be determined in accordance with ASTM D3549.
- R 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.
- S 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 m<sup>3</sup> 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.
    - b
 

<u>Tests</u>	<u>Method</u>
Bitumen content	ASTM D2172
Grading	ASTM C117 & C136
Density	ASTM D1188/D2726
Stability	ASTM D1559
    - c Loss of Marshall stability shall be tested for at least every 7,000 Mg.

- T Prime coat shall be applied at a rate of not less than  $0.7 \text{ l/m}^2$  and not more than  $1.5 \text{ l/m}^2$ . 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  $13^\circ \text{ C}$  or during rain, fog, dust storms or other unsuitable weather. Application temperature for MC-70 liquid asphalt shall be between  $50^\circ \text{ C}$  and  $80^\circ \text{ C}$  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 undisturbed 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.
- U The tack coat shall be applied in quantities of not less than  $0.3 \text{ l/m}^2$  and not more than  $0.6 \text{ l/m}^2$ . 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  $10^\circ \text{ C}$  and  $60^\circ \text{ C}$  as directed by the Engineer. Tack coat shall not be applied when the ambient temperature is less than  $13^\circ \text{ C}$  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.
- V 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  $110 \text{ kg/cm}$  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  $7.5 \text{ l/m}^2$  with a pressure range of  $1.25 \text{ kg/m}^2$  to  $5.2 \text{ kg/m}^2$ . 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.

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.

- W 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/m<sup>2</sup>.
- 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 at 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 m<sup>2</sup>.
- 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/m<sup>2</sup>. 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**

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## 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.
  - 2 Testing details shall include:
    - a procedures for adjusting and testing valve assemblies,
    - b a detailed procedure for the testing of systems including, as a minimum:
      - i equipment to be used, including calibration information, range, and sensitivity,
      - ii qualifications of the person performing the testing,
      - iii details of bulkheads, flanges, caps and the like to isolate systems for testing,
      - iv procedures to be followed,
      - v a schedule of times when tests will be performed, including durations,
      - vi 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**

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**

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

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**

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**

"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**

- A 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.
- B 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**

- A 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.
- B 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

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/m<sup>2</sup> 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

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.

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.

#### F 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.

## 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 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 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 "NWSDB". 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. 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 SLS 147 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 2494. 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 SLS 935 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 Section 7.2 of SLS 147:1983 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  $\pm 1$  percent for pipes up to and including 600mm diameter and  $\pm 0.5$  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  $\pm 25$  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 ( $N/m^2$ ), I the moment of inertia of the pipe wall per unit length ( $m^2/m$ ) 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/m <sup>2</sup> °C         |
- 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

- taken,
- e 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,
  - f 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
  - g 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
  - h 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/m<sup>3</sup>,
  - 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  $\pm 6$  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.
- J 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.
- K 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 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/ cm<sup>2</sup>:

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

- B Pipe supplied shall be Class 10 and maximum sustained working pressure is based on water at a service temperature of 30° 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;<br>all other fittings Hoechst T 1020 black R2 Acetal Terpolymer.                           |
| 3 | components        | -grip ring; Acetal polymer "O" ring;<br>EDPM elastomer to BS 2492 type W, such as Millflex M28, Victaulic EP52, Exxon 584/111 EDPM or Wooduolle Polymer 09-333. |

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.

## 2.09 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.

## 2.10 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.

## 2.11 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.

## 2.12 Consumer Meters

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.

## 2.13 Mechanical Couplings

- A Grooved end couplings shall engage and lock the grooved or shouldered pipe ends allowing some degree of contracting, extension, and angular deflections. 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.
- B 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.

- C 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.
- D 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.
- E 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.

#### **2.14 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.

#### **2.15 Marker Posts**

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

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.

## 2.16 Sewer Manhole Requirements

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/mm<sup>2</sup> 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 and have their paintwork or coating made good before assembly. Contractor shall use only the proper jointing materials (gaskets, nuts, bolts, washers, lubricants) as



- 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/m<sup>2</sup> 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.

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/mm<sup>2</sup>.
- 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.

#### D 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.

Diameter of tube (mm)	Centres (m)	
	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

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.

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 Each pipe line 600 mm or less in diameter shall be tested by air test. Should any pipe fail the air test, the Engineer may order the Contractor to perform a water test. Acceptance of the pipeline will then be based on the results of the water test. All pipelines 800 mm or greater in diameter 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  $0.1 \text{ litres/m}^2$  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  $\frac{1}{8}$  litre) regularly every 30 minutes 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:
- 0 All mains shall be flushed out with clean water until there is no evidence of foreign matter or color in the waste flushing water;
  - 1 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;
  - 2 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;
  - 3 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;
  - 4 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;
  - 5 The Contractor shall provide all equipment, materials and testing apparatus, etc., as may be necessary for the effective disinfection of all pipelines;
  - 6 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**

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 02830

### Chain Link Fence and Gates

#### Part 1 General

##### 1.01 Description

The work included in this section comprises furnishing all plant, equipment, appliances and materials and performing all operations in connection with chain link fencing.

##### 1.02 Quality Assurance

The manufacturer shall be a company specializing in commercial quality chain link fencing with five years experience and installation shall be in accordance with BS 1722: Part 10

##### 1.03 Submittals

- A. Two samples of the following shall be submitted:
1. Mesh size : 300 x 300 mm
  2. Line wire: 300 mm long
  3. Tying wire: 300 mm long
  4. Stirrup wire: 300 mm long
  5. Barbed wire: 300 mm long
  6. Fence fittings
- B. Shop Drawings shall include plan layout, grid, spacing of components, accessories, fittings, tension bracing, hardware, anchorages, height elevations of same and schedule of components.

#### Part 2 Products

##### 2.01 Materials

- A. Materials shall conform to BS 1722: Part 10 and be designed to withstand 120 km/hr wind speed with a 25 percent safety factor. All metal parts shall be galvanized to comply with BS 729. Fittings shall be 'clamp on type' and all chain link fence materials and fittings shall be coated with green plastic to comply with grade A of BS 4102. Fabric shall be 50 x 50 mm mesh and shall be woven from galvanized wire 3.0 mm core dia x 4.0 mm OD. Both ends of the fabric shall have knuckled selvage. Core wire shall have a minimum zinc coating weight of 92 g/sq m and a minimum breaking strength of 5700 N. Line wire shall be 3.55 mm core dia x 4.75 mm OD in four rows. Tying wire shall be 1.80 mm core dia x 2.60 mm OD. Stirrup wire shall be 2.50 mm core dia x 3.55 mm OD. Barbed wire shall comply with the requirements of BS 4102; be 1.80 mm core dia x 2.60 mm OD; and be 2-ply wires, 4- point barbs at 100 c/c. Three strands of barbed wire shall be provided along all perimeter fence; or as shown on the Drawings.
- B. Posts and brace rails shall be galvanized steel tubes galvanized in accordance with BS 729 and then polyester powder coated to a minimum thickness of 60 microns. Posts/Rails shall be of dimensions shown below:

Type of Post/Rail	OD (mm)	Wall Thickness (mm)	Spacing of Posts
Line Post	60	2.90	Maximum 3 m intervals
Intermediate Post	76	3.25	Maximum 65.0 m intervals
Corner Post	76	3.25	Any change in the line of the fence where the angle of deflection is more than 15°.
End Post	76	3.25	Where the fence begins or ends.
Brace Rail	42	2.65	To be installed on all Intermediate, Corner and End Posts.

- C. Extension arms shall be a continuation of the tubular post or clamp on type and shall form an angle of 40° to 45° with the vertical line of the post.
- D. Fence fittings shall be pressed steel or malleable iron fittings, hot dip galvanized to comply with BS 729 in the following dimensions:
  - Brace Bands 25 mm wide x 4 mm thick
  - Tensions Bands 25 mm wide x 4 mm thick
  - Truss Rods 10 mm dia
  - Tension Bar 20 mm wide x 4.5 mm thick
  - Carriage Bolts & Nuts M8 x 32 mm (galvanized only)
- E. Posts shall be of dimensions shown below.

WIDTH OF GATE	POSTS		STIFFENER
	OD (mm)	Wall Thickness (mm)	
Single Gate < 1.8 m	76	3.20	
Double Gate < 3.7 m			
4.0 m < Single Gate > 1.8 m			1 No. diagonal bar
7.9 m < Double Gate > 3.7 m	114	4.50	2 Nos. vertical bars
11.0 m < Double Gate > 7.9 m	166	4.85	3 Nos. vertical bars

Gate frames shall be 48 mm OD pipe with wall thickness of 3.25 mm. gate frames over 1.8 m wide shall be provided with centre vertical stiffener of 48 mm OD pipe with wall thickness of 2.9 mm. Gates shall be hung by at least two steel, or malleable iron, hinges not less than 80 mm in width, so designed as to securely clamp to the gate post, and permit the gate to the swung back against the fence. The bottom hinge shall have a socket to take the ball end of the gate frame. Gates shall be provided with: a combination steel, or malleable iron, catch and locking attachment of approved design; stops to hold gates open, and a center rest with catch shall be provided where required; and standard hardware and heavy duty padlocks. All padlocks shall conform to Federal Specification FF-P-101E and shall be master keyed. Padlocks shall be 50 mm, Types EPC, 5 pin tumbler mechanism, brass or bronze, solid case, with chain and as required by the Engineer.

**2.02 Polyester Powder Coating**

- A. Coating shall conform to BS 6496 and BS 6497 and be weather resistant; resistant to chalking from UV exposure; resistant against chemicals and have color stability from effects of heat. The coating shall have the following properties:

TEST	METHOD	TYPICAL RESULTS
Flexibility (Conical Mandrel)		Pass 3 mm
Adhesion (2 mm Crosshatch)	BS 3900 : Part E6 : 1992	Pass GTO
Erichsen Cupping	BS 3900 Part E4 : 1995	Pass > 7 mm
Hardness (400 gms)	BS 3900 : Part E2 : 1992	Pass - No Penetration to substrate
Impact Resistance	BS 6496 : Clause 16	Pass 2.3J direct and reverse
Salt Spray at 35° C	ASTM B 117	Pass at 1000 hrs.
Acetic Acid/Salt spray	BS 6496 : Clause 15	no corrosion area more than 2 mm from scribe
Cyclic Humidity	BS 8900 : Part F2 : 1973	Pass at 1000 hrs. no blistering or loss of gloss
Distilled Immersion	Water BS 3900 Part G5 : 1993	Pass - no blistering or loss of gloss after 24 hours
Sulphur Dioxide	BS 3900 : Part 8:1993	Pass - no blistering loss of gloss or discolouration after 240 hours.
Exterior Durability 12months Florida 40 deg. South	BS 6496 : Clause 4.10	Excellent performance. Slight even loss of gloss, no checking, cracking or flaking.
Chalking		None in excess of minimum in ASTM D659 : 1980

### Part 3 Execution

- A. Drilling and welding of GI tubes shall not be allowed.
- B. Spacing shall be as shown in the first table above, or as directed by the Engineer. Changes in line where the angle of deflection is 15 degrees or more shall be considered as corners and corner posts shall be installed. All intermediate corner and end posts shall be braced in the direction of the line of fence, using brace rail pipes as compression members and truss rods with turn buckles as tension members. Intermediate and corner posts shall be horizontally braced to the nearest line posts in both directions. End posts shall be horizontally braced in one direction only. Standard straining fittings like truss rod, turn-buckle, tension bar, brace and tension bands, rail ends, brace rail ends, nuts and bolts etc. shall be used for all posts.
- C. Fabric shall be stretched and securely fastened to posts at 350 mm intervals and brace rails at 500 mm intervals, using stirrup wire. Between posts, the fabric shall be fastened to top and bottom line wires at 150 mm intervals and other line wires at 450 mm intervals, using tying wires.
- D. Concrete foundations shall be as followings:
- Line Posts : 300 mm diameter x 900 mm deep.
  - Intermediate, Corner, and End posts : 400 mm diameter x 1000 mm deep.
  - Gate Posts : 600 mm diameter x 1100 mm deep.
- A continuous concrete sill 200 mm wide x 300 mm high for the full length between the posts shall be cast with the top at ground level approximately 25 mm below the bottom of the chain link mesh. Grade 25 sulphate resisting Portland Cement concrete shall be used for post footings and sill.

**End of Section 02830**

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## Section 02850

### Gabions

#### Part 1 General

##### 1.01 Description

The work included in this section comprises furnishing all plant, equipment, appliances and materials and performing all operations in connection with gabion mattresses and box gabions.

##### 1.02 Quality Assurance

The manufacturer shall be a company specializing in commercial quality gabions with five years experience.

##### 1.03 Submittals

- A. Two samples of the following shall be submitted:
  - 1. Wire fabric: 600 x 600 mm
  - 2. Binding wire: 600 mm long
- B. Shop Drawings shall include plan layout, grid, spacing of components, accessories, fittings, height elevations of same and schedule of components.

#### Part 2 Products

##### 2.01 Gabions

The gabions shall be flexible zinc coated gabions of the sizes as stated in contract documents and fabricated of wire mesh of the type and size, and selvedged as specified below. Each gabion shall be divided by diaphragms into cells whose length shall not be greater than the width of the gabion plus 100 mm, or otherwise as stated.

##### 2.02 Wire Fabric for Gabions

- A. The fabric shall be triple-twisted hexagonal woven, 2.7 mm diameter steel wire mesh complying with BS 1485. The wire shall be galvanized before weaving, and test samples shall meet the requirements of BS 443, followed by a PVC coating. Wire thickness and mesh size shall be as follows:

	Minimum Wire Diameter	Mesh Size
Gabion mattress	2.0 mm	60 x 80 mm
Box gabions	2.7 mm	80 x 100 mm

- B. The wire mesh shall have elasticity to permit elongation of the mesh equivalent to a minimum of 10 percent of the length of a section of mesh under test without reducing the diameter or tensile strength of the individual wires.
- C. All edges of the gabions, diaphragms and end panels shall be selvedged with a wire of diameter not less than 20 percent greater than that of the mesh wire.
- D. The selvedging must be such that the mesh will not unravel and such that the strength of the connection between the selvedge wire and the mesh shall be equal to or greater than the

breaking strength of the mesh.

### 2.03 Binding and Connecting Wire

- A Sufficient binding and connecting wire must be supplied with the gabions to perform all the wiring operations to be carried out in the construction of the gabion work. The diameter of the wire should be minimum 2 mm.
- B Binding and connecting wire shall be manufactured by the manufacturer of the gabions, unless otherwise approved by the Engineer.

### 2.04 Tolerances for Gabions and Gabion Wire

Gabions and gabion materials shall be manufactured to the following tolerances:

- 1 Gabion dimensions  
A tolerance of  $\pm 5$  percent on the width and height of the gabion and a tolerance of  $\pm 3$  percent on the length shall be permitted.
- 2 Mesh dimensions  
A tolerance of  $\pm 15$  percent on the nominal size of the mesh shall be permitted.
- 3 Wire thicknesses  
A tolerance on the diameter of all wire in the above clauses of  $\pm 2.5$  percent shall be permitted in accordance with BS 1052. The weight of gabions is therefore subject to a tolerance of  $\pm 5$  percent.

### 2.05 Stones for Gabions

Stone used for gabions and gabion mattress shall be clean, natural, hard and durable with a minimum density of  $2400 \text{ kg/m}^3$  and shall be approved by the Engineer. Stone shall be well graded within the following limits:

	Minimum Dimension	Maximum Dimension
250 mm mattress	125 mm	200 mm
Box gabions	150 mm	300 mm

## Part 3 Execution

### 3.01 Method of Construction of Gabions

- A The embankment against which the gabions are to be placed shall be suitably trimmed and the base shall be properly levelled by packing with rubble to a thickness of 300 mm before placing the gabion. The surface below and behind the gabion box and which is in contact with the backfill material shall be covered with a geotextile fabric conforming to the requirements of Section 02520. After placing the geotextile fabric the backfilling behind the gabions shall be carried out in accordance with Section 02222
- B Gabion mattresses and box gabions shall have internal diaphragms of the same mesh as the enclosing fabric. Diaphragms shall be positioned such as to give compartments in gabion mattresses with a maximum width of 1 m and a maximum length of 3 m. In box gabions the maximum compartment size shall be 1.0 m x 1.0 m x 1.0 m.
- C Adjoining gabions shall be firmly wired together to give a continuous join along all adjacent edges. Binding wire shall be laced around selvages or wire mesh with single loops and double loops in turn at intervals equivalent to one mesh length. Units should be placed on headers and stretchers in alternate courses, and vertical joints should not be continuous but staggered.

- D Before filling, the gabions shall be accurately positioned in their required location, straightened to remove all kinks in the wire mesh and tensioned to avoid bulges occurring during filling. The method adopted for tensioning the gabions shall be to the approval of the Engineer. Completed gabions shall be inspected and approved by the Engineer before filling commences.
- E Gabions may be filled by hand or by machine, but whichever method is adopted, the stones must be tightly packed to minimize the formation of voids. Particular care must be taken to avoid the use of flat stones as these do not compact properly and cause the gabions to bulge.
- F Gabions shall be overfilled by 25 to 50 mm to allow for settlement. Gabion lids shall be stretched tightly over the fill material and securely wired down. If voids are formed between the fill and the gabion lid, then these may be filled with small stones provided that no small stones occur on an exposed face.
- G Where shown or otherwise directed by the Engineer, the gabion mesh shall be cut, folded and wired together to form mitre joints, angles, curves or slopes which are not possible to obtain in the structures with the standard rectangular gabions. The mesh must be cleanly cut, and the surplus mesh cut completely out, or folded back or on to, and neatly wired to an adjacent gabion face. The cut edges of the mesh shall be securely laced together with binding wire.

**End of Section 02850**

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## Section 02900

### Landscaping and Planting

#### Part 1 General

##### 1.01 Description

The work included in this section comprises furnishing all plant, labor, equipment, appliances and materials and performing all operations in connection with landscape works and planting soil mix.

##### 1.02 Ordinances and Regulations

All ministry and local authority laws, rules and regulations governing, or relating to, any portion of this work are hereby incorporated into, and made a part of, these specifications and their provisions shall be carried out by the Contractor. Anything contained in the Specifications shall not be construed to conflict with any of the above rules and regulations or requirements of same. When the Specifications and/or Drawings, call for, or describe materials, workmanship or construction of a better quality, higher standard or larger size, Specifications and/or Drawings shall take precedence over the requirements of said rules and regulations.

##### 1.03 Job Conditions

Prior to any landscape work, the Contractor shall locate all existing underground installations and protect the same. Any damage to these installations shall be repaired at no extra cost to the Employer. Work with other trades shall be coordinated so that conflicts will not exist nor delay the work in any way. At all landscaped areas, the landscape contractor shall be responsible for providing final grades in accordance with the requirements of the Drawings, soils report and site work specification requirements.

##### 1.04 Quality Assurance

- A Work must be performed with experienced personnel. The Contractor must show proof of the qualifications and experience of all personnel proposed for this contract. This must include details of major landscape and irrigation projects, on which the person has worked, the respective client, construction cost of each project and the specific responsibility and position of the person in question. These items must be included within each individual's curriculum vitae in addition to experience and/or education. This information must be submitted to the Engineer or Resident Engineer for review and approval at least six weeks prior to construction.
- B This Contract will require a minimum of the following personnel:
- 1 landscape architect who must have a BS degree in agriculture, ornamental horticulture or landscape architecture and a minimum of eight years experience in landscape construction. Must have a minimum of four years experience as overall project manager on major landscape projects. Experience in farming operations shall not be acceptable. Seven years of additional experience in landscape construction may substitute for the degree.
  - 2 landscape foreman must be skilled in the installation of planting and associated landscape elements with a minimum of ten years experience in landscape construction.
    - a layout/planting pits/cleanup foreman
    - b planting foreman - small plants (under 2 m)
    - c planting foreman - large plants (2 m and over)

- 3 all landscape labourers must be skilled in the installation of planting and associated landscape elements with a minimum of two years experience in landscape construction.
  - 4 horticulturist/arborist must have a BS degree in ornamental horticulture and a minimum of three years field experience. Five years additional field experience in ornamental horticulture may be substituted for BS degree. Forestry or agriculture degrees or experience may not be substituted.
- C The Contractor must show proof of his ability to mobilize the following list of equipment (or a list which has been previously approved by the Engineer) and shall have equipment on site when beginning a particular part of the work for which that piece of equipment is necessary:
- |                                                  |                                                 |
|--------------------------------------------------|-------------------------------------------------|
| 1 air compressor                                 | 11 back hoes                                    |
| 2 mini loaders                                   | 12 concrete mixer                               |
| 3 dumper                                         | 13 dump trucks                                  |
| 4 earth compactor                                | 14 jack hammer                                  |
| 5 loaders                                        | 15 rotovator                                    |
| 6 trenchers - sizes as needed                    | 16 truck                                        |
| 7 tractor with disk harrow                       | 17 augers of required sizes                     |
| 8 water tanker with spray mister hose attachment | 18 rotary type mowers                           |
| 9 pruning Equipment                              | 19 tractor trailer for transporting large trees |
| 10 crane for loading and planting large trees    |                                                 |

### 1.05 Submittals

The Contractor shall submit the following:

- 1 manufacturer's certified analysis of standard packaged products
- 2 an independent laboratory analysis of all materials submitted
- 3 manufacturer's or vendor's certified analysis for fertilizer materials
- 4 an analysis of the organic amendment material prior to shipping to the project
- 5 prior to placement of prepared soil mix in the landscape, a laboratory analysis showing items in fertility and agricultural suitability as required
- 6 1.5 l water sample of irrigation water
- 7 1 kg fertilizer sample.

### 1.06 Delivery, Storage and Handling

Packaged materials will be delivered in labeled sealed containers showing the weight, analysis and name of manufacturer, point of origin and dealer, including expiration date. Fertilizer shall be stored separately from pesticides in a dry storage area away from contaminants and plant materials as approved by the Engineer. All pesticides shall be stored in a locked container in an air-conditioned room. Herbicides shall be stored separately from other chemicals and all storage areas shall be locked. Bulk materials stockpiled on site shall be covered and protected to prevent deterioration from sun and wind.

### 1.07 Guarantee

- A Guarantee period for all plant material shall begin at the date of acceptance of the planting operation as complete. Planting operations will be accepted as complete when the Contractor receives a Notice of Substantial Completion from the Engineer.
- B All plant material shall be guaranteed by the Contractor, for a period of two years from the date of notice of substantial completion, to be in good, healthy, and flourishing condition. When the work is accepted in parts, the guarantee periods shall extend from each of the partial

acceptances to the terminal date of the last guarantee period. Thus, all guarantee periods terminate at one time.

- C The Contractor shall replace, immediately and without extra cost to the Employer all dead plants and all plants not in vigorous, thriving condition. Plants shall be free of dead or dying branches and branch tips and shall bear foliage of a normal density, size and colour. Replacements shall match adjacent specimens of the same species, shall be provided immediately and shall be subject to all requirements stated in this Specification. Guarantees of all replacement plants shall extend until the end of the two year guarantee period. Any plant not found in an acceptable condition during the guarantee period will be replaced immediately. If said replacement occurs within 120 days of the end of the guarantee period this period will be extended by 120 days from the date the last plant was installed.
- D The Contractor shall make all necessary repairs due to plant replacements and such repairs shall be done at no extra cost to the Employer and within a reasonable time as determined by the Engineer.

### **1.08 Acceptance**

- A The Engineer shall inspect all work for substantial completion upon written request of the Contractor and such request shall be received at least ten calendar days before the anticipated date of inspection. Acceptance of plant material by the Engineer will be for general conformance to specified size, character and quality and this shall not relieve the Contractor of responsibility for full conformance to the contract documents including correct species. Upon completion and re-inspection of all repairs or renewals necessary in the judgement of the Engineer, the Engineer will recommend to the Employer that he accept the work as substantially complete. Work may be accepted as substantially complete in parts when it is deemed to be in the Employer best interest to do so, and when permission is given to the Contractor in writing to complete the work in parts. Acceptance and use of such areas by the Owner shall not waive any other provisions of this contract. The guarantee period shall commence upon acceptance as substantially complete.
- B At the end of the maintenance and guarantee periods, the Engineer will inspect all work for Final Acceptance upon written request of the Contractor and such request shall be received at least thirty calendar days before the anticipated date for Final Inspection. Upon completion and re-inspection of all repairs or renewals necessary in the judgement of the Engineer, the Engineer shall certify in writing to the Owner as to the Final Acceptance of the work.

### **1.09 As-built Drawings**

The Contractor shall keep Mylar reproducible of the Drawings exclusively for the purpose of recording all changes and deviations in the locations of plants or materials. All changes shall be indicated thereon as the job progresses. The Contractor shall deliver these modified reproducible to the Engineer upon completion of the work.

## **Part 2 Products**

### **2.01 Prepared Soil Mix Components**

- A Material for prepared soil mixes shall be obtained from approved borrow sources and shall conform to the following physical and chemical characteristics:
  - 1 salinity (ECe x 1000) less than 2
  - 2 SAR (sodium absorption ratio) less than 1
  - 3 boron (saturation extract) less than 0.5 mg/l

4 pH less than 8

<u>Sieve Size</u>	<u>% by Weight Passing</u>
No. 10	100
No. 35	90-100
No. 140	0-10
No. 270	0-3

B Organic Amendment - Bark Mulch. Organic amendment shall be coniferous fir bark mulch with the following chemical and physical characteristics:

1 bulk density:	300-400 kg/m <sup>3</sup>
2 organic matter	greater than 80 percent
3 pH	5.0-6.5
4 salinity (ECe x 1000)	0.5-2.0
5 total nitrogen	0.7-2.0
6 available phosphorous	100-500 mg/l
7 CEC (meg/100 gms)	80-120 mg/l
8 boron (by hot water extraction)	less than 5 mg/l
9 SAR	less than 2.0

<u>Sieve Size</u>	<u>% by Weight Passing</u>
9.5 mm	100
6.35 mm	90-100
2.4 mm	50-60

C Fertilizers shall be provided as indicated below for soil mix:

- 1 organic resin coated complete fertilizer with an analysis of 20-10-5+Fe and a release longevity of 12-14 months at 21° C soil temperature
- 2 agriculture grade sulphur, 99 percent sulphur content with 100 percent passing a 16 mesh screen and 50 percent passing a 100 mesh screen
- 3 controlled release fertilizer shall be Osmocote as manufactured by Sierra Chemical Company, Strijkviertel 35 II, 3454 PJ De Meern, Netherlands, or approved equal.

### Part 3 Execution

#### 3.01 Preparation

A Soil mix shall conform to the following requirements:

1 salinity (ECe x 1000)	less than 4.0
2 SAR	less than 4.0
3 pH	6.5 to 7.5
4 boron (by saturation extraction)	less than 0.7 mg/l

B Soil mix is to be mixed in the quantities of proportions as indicated below according to the procedures outlined in paragraph 3.01 E:

- 1 65 percent sand
- 2 35 percent coniferous fir bark mulch
- 3 2 kg controlled release fertilizer per cubic metre.
- 4 2 kg soil sulphur per cubic metre

C In the event that the pH of soil mix exceeds 7.5 the portion of the mix will be amended with suitable additives (soil sulphur, sulphuric acid, or other approved amendments) to bring the resultant soil mix into the specified range of 6.5 to 7.5. Such additives will be added prior to addition of the organic amendment. After adding such additives the mixture will be leached to bring the salinity, SAR, pH and boron of the resultant mix within the ranges indicated in paragraph 3.01 A.



- D One trial lot, of two cubic metres shall be prepared by the Contractor prior to the start of full soil mixing operations. Samples of these trials shall be submitted for analysis. The Contractor shall submit such analysis and recommendations to the Engineer. An analysis will include specific recommendations for changes in the soil mix formulations. The Contractor may begin full soil mixing operations after obtaining approval.
- E The physical ingredients shall be mixed to a uniform mixture. The mixing method shall be by wind rowing/tilling on an approved hard surface area and according to acceptable horticultural practices as approved by the Engineer. The organic portion should be moist. Apply fertilizer ingredients and mix until homogenous. The resultant mix will be moistened to about 5 to 10 percent.

### **3.02 Clean up**

- A The Contractor shall clean up all areas on a, regularly, scheduled basis, or whenever deemed necessary by the Engineer, as well as upon completion of the work before acceptance and during the guarantee period. Adjacent walks, paved surfaces and road shoulders shall be kept clean during the installation of landscape works. Waste materials shall be removed daily and the Contractor shall restore previously established grade elevations caused by irrigation equipment, rainfall, or other natural or man made causes, such as contour grading. Prepared planting soil mix and mulch top dressing shall also be restored to levels and conditions shown on the plans and in the specifications. This work shall be incidental to all other work, and no additional compensation shall be made for it.
- B The Contractor shall protect new plants from injury during installation and until acceptance of the work as specified herein.

**End of Section 02900**

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## Section 03100

### Formwork

#### Part 1 General

##### 1.01 Description

- A 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/m<sup>2</sup>, or an additional live load of 3.75 kN/m<sup>2</sup> if a motorised cart is used.
  - 4 The minimum design load for combined dead and live load shall be 6.50 kN/m<sup>2</sup>, or, if a motorised cart is used, 7.75 kN/m<sup>2</sup>.
  - 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 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 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**

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## 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.
- 2 The Engineer reserves the right to sample and inspect all reinforcement steel upon its arrival at the work site.
- 3 The Contractor shall provide a certificate confirming that samples taken from the bars delivered to the works pass the re-bend test.
- 4 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**

- 1 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.
- 2 Fabricator shall furnish three copies of a certification which shows the production numbers from which each size of bar in the shipment was fabricated.

**B 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.

- C** 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 <sup>2</sup>	R
Deformed high yield bars	460 N/mm <sup>2</sup>	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 use 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**

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## 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,
- 4 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 Grade	Max. Size Agg. mm	Min. Cement Content kg/m <sup>3</sup>	Max. Free Water/Cement Ratio	Cube Crushing at 28 days		
				Trial N/mm <sup>2</sup>	Mix N/mm <sup>2</sup>	Works Test N/mm <sup>2</sup>
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 95percent 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 a 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/m<sup>2</sup> 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 4027	
		I	II	III	IV	V	OPC	RHP	SRP	low
Silica, S, (SiO <sub>2</sub> )	≥	-	21.0	-	-	-	-	-	-	-
Alumina, A, (Al <sub>2</sub> O <sub>3</sub> )	≤	-	6.0	-	-	-	-	-	-	-
Ferric Oxide, (Fe <sub>2</sub> O <sub>3</sub> )	≤	-	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 <sub>3</sub> )										
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	≤	0.75	0.75	0.75	0.75	0.75	1.5	1.5	1.5	1.5
Tricalcium silicate (C <sub>3</sub> S)	≤	-	-	-	35.0	-	-	-	-	-
Dicalcium silicate (C <sub>2</sub> S)	≤	-	-	-	40.0	-	-	-	-	-
Tricalcium aluminate (C <sub>3</sub> A)	≤	-	8.0	15.0	7.0	5.0	-	-	3.5	-
Tetra calcium aluminoferrite C <sub>4</sub> AF+2(C <sub>3</sub> A)	≤	-	-	-	-	20.0	-	-	-	-
C <sub>3</sub> A for moderate sulphate resistance	≤	-	-	8.0	-	-	-	-	-	-
C <sub>3</sub> A for high sulphate resistance	≤	-	-	5.0	-	-	-	-	-	-
C <sub>3</sub> S+C <sub>3</sub> A for moderate heat of hydration	≤	-	58.0	-	-	-	-	-	-	-
Alkalis (NaO <sub>2</sub> +0.658K <sub>2</sub> 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 <sub>2</sub> S	dicalcium silicate	F	ferric oxide
C	lime	C <sub>3</sub> S	tricalcium silicate	H	water
C <sub>3</sub> A	tricalcium aluminate	C <sub>4</sub> AF	tetracalcium aluminoferrite	S	silica

		ASTM Type					BS 12		BS 4027	BS 1370
		I	II	III	IV	V	OPC	RHPC	SRPC	low heat
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 (m <sup>2</sup> /kg)	≥	280	280	-	280	28	225	325	250	27

		ASTM Type					BS 12		BS 4027	BS 1370
		I	II	III	IV	V	OPC	RHPC	SRPC	low heat
Turbidimeter ( $m^2/kg$ )	$\geq$	160	160	-	160	16	-	-	-	-
Soundness										
Autoclave expansion (%)	$\leq$	0.8	0.8	0.8	0.8	0.8	-	-	-	-
Le Chatelier (mm)	$\leq$	-	-	-	-	-	10	10	10	10
Compressive strength (Mpa)	$\geq$									
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)	$\leq$									
(1 cal/g = 4.2kJ/kg)	7 d	-	293	-	251	-	-	-	-	250
	28	-	335	-	293	-	-	-	-	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 Fine aggregate shall be natural crushed sand.
- 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 Natural, uncrushed/ Crushed Crushed rock	Part 103 (wet)		max. 3%	Max. 1%
3. Clay lumps and friable particles		C142	max. 5% max. 3%	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/C12 7	max. 2%	Max. 2%
7. Specific Gravity (apparent)		C128/C12 7	min. 2.6	Min. 2.6
8. Shell content: Coarser than 10 mm Between 5 mm & 10 mm Between 2.36 mm & 5 mm Finer than 2.36 mm	Part 106		max. 10% Note 1	Max. 3% max. 3%
9. Particle shape: Flakiness index Elongation index	Part 105.1 Part 105.2			Max. 25% Max. 25%
10. Acid Soluble Chlorides: A. For reinforced concrete with: SRPC OPC & MSRPC  B. For mass concrete made with: SRPC OPC & MSRPC  C. For prestressed & Steam cured structural concrete	Part 117, Appendix C		max. 0.06% max. 0.06%  Max. 0.06% Max. 0.06%  max. 0.01%	Max. 0.03% max. 0.03%  Max. 0.03% max. 0.03%
11. Acid Soluble Sulphates	Part 118		max. 0.3%	Max. 0.3%

	Requirement	Test Methods		Permissible Limits	
		BS 812	ASTM	FINES	COARSE
12.	Soundness, (MgSo4 - 5 Cycles		C88	max. 10%	Max. 10%
13.	Mechanical Strength:10% fines value	Part 111			Min 150 kN
	Impact value	Part 112			Max. 30%
	Loss Angeles Abrasion		C131/C53 5		Max. 20%
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 0.10% max.	expansion

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 <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> whichever is more frequent
8.	Particle Shape	BS 812 : Part 105.1 & 105.2	-do-
9.	Acid Soluble Chlorides, Cl	BS 812 : Part 117, Appendices A/B	On each delivery to site
	Quantitative	BS 812 : Part 117, Appendix C	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 more than 75% of the limit & each two months if result is less than 75% of the limit.
11.	Soundness (Mg S04 - 5 cycles)	ASTM C88	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

Requirement	Test Method	Test Frequency
15. Potential Reactivity: Of aggregates Of carbonate Of cement aggregate combination	ASTM C295/C289 ASTM C586 ASTM P124/C227	change in the source of supply.  At the start of the project and wherever there is a change in the source of supply.

## 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

- A Gradation shall be in accordance with BS 882 excluding grading designation F. Fine aggregate shall be clean, sharp, natural and/or crushed sand.
- B 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.
- C 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	Percentage Weight Passing BS Sieves
--------	-------------------------------------

Test Sieve	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 7.0 or more than 9.0.
- 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 <sub>3</sub> )	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

- C. Every effort should be made to protect water pipes and tanks from the sun, e.g., burying, shading, insulation or painting white.
- D. 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.
- E. 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.
- F. Water of questionable quality should comply with the physical and chemical limitations listed above.
- I. 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/m<sup>3</sup> 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 13.8 N/mm<sup>2</sup>. Elongation at break shall be minimum 300 percent and Shore A hardness shall be 80-90. The waterstop shall be fully continuous and coordinated four bulbed section. Testing shall carried out in accordance with BS 2782, US Corps of Engineers specification CRD C572-74.
- 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/mm<sup>2</sup> 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 250 mm wide with

four bulbs and ten parallel lines of fins. Centre box 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 shuttering 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 250 mm wide with four bulbs and ten parallel lines of fins and shall incorporate a central fin 22 mm high, as a shutter stop. They shall have an outer nailing flange with a reinforced and profiled edge to resist tear when fixed to shuttering 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 250 mm wide with four bulbs and ten parallel lines of fins. The centre box 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 250 mm wide with four bulbs and ten 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. Joint 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 <sup>3</sup> ± 5 kg/m <sup>3</sup>
Water Absorption	less than 1%
- 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  $0.7 \text{ N/mm}^2$ . 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  $50^\circ\text{C}$ .

- 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 <sup>2</sup> (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 = ~ $4 \text{ N/mm}^2$ (concrete failure)
Bond Strength to Steel	~ $6 \text{ N/mm}^2$ (strip failure)
Tensile Strength	~ $6 \text{ N/mm}^2$
Peel Strength	~ $4.5 \text{ N/mm}^2$
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.

J 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.

K 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.

L. All costs connected with the preparations of trial mixes shall be borne by the Contractor.

M 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,
  - 13 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 1.64 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/mm<sup>2</sup> 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/mm<sup>2</sup> 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/mm<sup>2</sup> 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/mm<sup>2</sup> 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 (SO<sub>3</sub>) content of each mix is within the specified limits. Chloride tests shall be performed in accordance with BS 812:Part 117 and sulphate (SO<sub>3</sub>) 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 <sub>3</sub>
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 consequentially 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.
- 5 If the average strength of the three works test cubes fail at 7 days:
  - a immediately stop all concreting until checks are made on material and equipment,
  - b 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.
- 6 If works test cubes fail at 28 days as specified in paragraph 3.11 herein:
  - a suspend concreting operations and do not proceed further without approval,
  - b 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,
  - c replace all defective work,
  - d 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 trowelled 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 uncompacted concrete vertically and at regular intervals. Where the uncompacted 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 uncompacted 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 waterstops in construction joints to satisfy the requirements of these

Specifications, then waterstops 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 1/5 to 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-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance 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**

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## Section 03320

### Concrete Topping

#### 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 concrete floor screeds and accessories.

##### 1.02 Quality Assurance

- A Only materials of known quality shall be incorporated in the work.
- B All materials shall be properly selected, reviewed with the Engineer before use and maintained during shipment, storage and use.
- C Regardless of reviews by the Engineer, the Contractor shall be responsible for all materials, methods and the work.
- D If any work does not satisfy the Contract Documents, implement removal, replacement or remedial work and revise procedures or materials to prevent recurrence of unacceptable work.

##### 1.03 Submittals

- A Samples of concrete accessories of every type to be used.
- B Certified mill test reports for cement.

##### 1.04 Delivery, Storage and Handling

- A Deliver all packaged materials to the site in original unopened containers, clearly indicating manufacturer's name, brand name and other identifying information.
- B Store materials in a dry, well-ventilated location, off the ground and in such manner as to prevent damage or intrusion of foreign matter.
- C All materials which, in the opinion of the Engineer, have become damaged or otherwise unfit for use during delivery or storage shall be replaced.

#### Part 2 Products

##### 2.01 General

The 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.

## 2.02 Materials

- A Portland cement shall be to BS 4027 or ASTM C150, Type V, non-staining. Only one brand of cement from one mill shall be used throughout the work, unless otherwise approved by the Engineer.
- B Coarse aggregate shall be to BS 882 or ASTM C33 and shall be evenly graded crushed gravel or stone, or a combination thereof passing a 9.5 mm sieve and retained on a 4.5 mm sieve.
- C Fine aggregate shall be natural sand to BS 882 or ASTM C33
- D Water shall be clean, fresh and free of harmful matter such as oil, salts, acids, alkali, sewage, deleterious minerals or organic matter and shall conform to BS 3148.
- E Curing material shall be:
  - 1 polyethylene sheeting to ASTM C171, 0.10 mm thick, opaque black,
  - 2 reinforced waterproof building paper to ASTM C171 and or BS 1521, Grade A1 opaque,
  - 3 burlap to AASHTO M 182.
- F Dustproofer shall be a product of Fosroc International Limited or other equal to the approval of the Engineer.
- G Hardener and sealer shall be a product of Fosroc International Limited or other equal to the approval of the Engineer.
- H Mixes:
  - 1 Grout shall be one part cement to one part sand, with sufficient water to make a stiff slurry.
  - 2 Bond coat shall be one part cement to 1¼ parts sand to two parts coarse aggregate mixed with bonding agent as approved by the Engineer. The amount of water shall not exceed 19 litres per 50 kg. bag of cement.
  - 3 Top coat shall be same mix as specified for the bond coat.
  - 4 Stair platforms, landings and treads without finish covering shall be made "non-slip" by using 1.2 kg. of a fine abrasive aggregate for each square metre of area. Abrasive aggregate shall consist of a vitreous ceramic grit containing 60 to 70 percent aluminium oxide abrasive.
- I Mesh reinforcement shall conform to BS 4483.
- J Pigmented concrete shall contain pigments for integrally coloured concrete and which shall be submitted for the Engineer's approval and shall be certified in writing by the manufacturer to be in compliance with ASTM C 979.

## Part 3 Execution

### 3.01 Condition of Surfaces

The Contractor shall examine the substrate, adjoining construction and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory conditions have been corrected.

### 3.02 Preparation

- A The substrates shall be cleaned to remove grease, laitance and other substances which may adversely affect the adhesion of the work by using a dilute solution of muniatic acid, chipping of the surface, or any other method of cleaning required.
- B The surfaces shall be left thoroughly clean and wet with as much water as will be absorbed. The substrates shall be kept wet continuously overnight, but in no case for less than six hours, before work is applied.

### 3.03 Application

The wet substrate surfaces shall be completely covered with grout, applied with force and brushed in to ensure full coverage. The bond coat shall be applied not less than 16 mm thick immediately after application of grout and brought to true lines, levels and profiles. The bond coat shall be thoroughly compacted and roughed to form a key for the top coat. Before the bond coat has set, the top coat shall be applied to such thickness that the total of the work measured from substrate to finished surface will be as shown, less only thickness of finish covering.

### 3.04 Finishing

- A General
  - 1 Consolidate concrete with vibrating screeds or roller screeds.
  - 2 Power float and hand float after water sheen has disappeared to push down aggregate, raise mortar and level.
  - 3 Power trowel and hand trowel as soon as surface can be worked without cement base clinging to blades.
  - 4 Tolerances in surfaces for hand trowelled and non-slip finishes shall not exceed 3 mm in 3 metres in any direction. Elsewhere, tolerances shall not exceed 6 mm in 3 metres in any direction.
  - 5 Saw-cut control joints 5 mm wide, 20 mm deep in hardened topping using diamond-bladed power saw at locations approved by the Engineer.
- B Finishes
  - 1 Hand trowelled.
    - a Trowel smooth finish free of trowel marks and other defects until a ringing sound is produced.
    - b Moist cure with hardener and sealer
  - 2 Non-slip finish.
    - a Wood float to rough granular finish, and let set.
    - b Moist cure with hardener and sealer.
  - 3 Trowelled - for all floors to receive carpet or resilient floor finish.
    - a Float to smooth granular finish.
    - b Trowel to smooth finish, free of trowel marks, pockets or humps.
    - c Cure and seal in 2 coats.
    - d Use self levelling compound to bring to final true level.
  - 4 Other surfaces to receive subsequent finishes e.g. cement and sand beds for quarry tiles, ceramic tiles, etc.
    - a Consolidate and level.
    - b Use stiff broom to roughen surface and expose aggregate.
    - c Moist cure only.
    - d Do not use chemicals for curing.

**3.05 Curing and Protection**

Work shall be cured by covering with polyethylene sheeting and flooding for at least seven days after finishing. After curing the work shall be kept covered to protect it from damage during the progress of other work.

**3.06 Dustproofing**

When the work is cured and dry, two coats of dustproofer shall be applied in accordance with manufacturer's instructions for hand trowelled and non-slip finishes.

**End of Section 03320**

## 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 160 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 85°C 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/mm<sup>2</sup>. 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 50 N/mm<sup>2</sup> characteristic cube strength minimum at 28 days and 40N/mm<sup>2</sup> 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

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

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

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**

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## 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**

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## Section 03800

### Architectural Concrete Finishes

#### Part 1 General

##### 1.01 Description

- A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with Architectural Concrete Finishes.
- B The intent of this Specification is to secure for the job, materials and workmanship of such quality that only nominal finishing will be required to produce concrete surfaces equal to the best obtainable with the concrete and forming materials specified.
- C Surfaces which reveal, upon removal of forms, imperfections of such magnitude as to seriously impair the appearance of the structure, in the opinion of the Engineer, shall be deemed to be a cause for rejection.
- D Concrete members containing such imperfections shall be entirely removed and replaced without damage to adjacent materials or extra expense to the Employer.
- E Lesser imperfections of concrete surface shall be patched and finished in accordance with the following procedures and with the approval of the Engineer.

##### 1.02 Submittals

- A Samples as requested by the Engineer shall be provided of each finish specified herein. Samples shall be 500 x 500 x 100 mm thick, cast from concrete made in accordance with the approved mix design, using the approved materials, and shall be cured using the methods proposed for the Works. Each panel shall show treatment of typical tie-rod hole, rustication joint and corner as well as typical patch of void. One panel for each finish shall be sandblasted each side with slightly different degree of blasting for selection and approval by the Engineer.
- B Prior to construction of any work above grade, a mock-up shall be constructed on the site, at a place selected by the Engineer. The mock-up shall include typical portions of exterior column, beam and flat wall panel all connected together. All materials, formwork, reinforcing and accessories used for the mock-up shall be those approved for use in the actual construction. The mock-up panel shall be used for sampling and approving patching materials and techniques.
- C The Contractor shall remove rejected panels and mock-ups from the site when directed by the Engineer.

##### 1.03 Safety During Sandblasting Operations

Sandblasting shall comply with all local and national anti-pollution laws and shall be carried out in suitable enclosures for collecting grit and dust from the blasting operation. The Contractor shall be responsible for safety of the workmen engaged during sandblasting and shall equip each man with an air-fed helmet.

#### **1.04 Delivery, Storage and Handling**

Work under this Subdivision shall be delivered and stored in a manner to prevent wracking or stress components, and to prevent mechanical damage or damage by the elements. Work under this Subdivision shall be delivered to site in ample time to avoid delay in job progress and at such times as to permit coordination of the various parts.

### **Part 2 Products**

#### **2.01 Materials**

- A Cement, sand, color pigments and water for surface preparation shall be as specified in Section 03300. Work to receive exposed aggregate finish shall be cast from a gap-graded mix to match precast architectural concrete.
- B Sandblasting grit shall be a fine abrasive grit of uniform grain size which shall not adversely affect the color of the finished surfaces as approved by the Engineer. The grit used shall be uniform throughout the work.

#### **2.02 Patching Mortar Mix**

- A Patching mortar shall be of the same material and proportions as used for the concrete without coarse aggregate. A sufficient quantity of white cement shall be substituted for part of the grey cement so that the patching mortar, when dry, will match the surrounding concrete.
- B Rubbing grout shall be a paste of one part Portland Cement and 1½ parts sand, mixed with clean clear water to a consistency which will not be too stiff to allow application with a stiff bristle brush.
- C Patching mortars shall conform to approved samples.

### **Part 3 Execution**

#### **3.01 Surface Preparation**

- A Each surface to be finished shall be patched as further specified below for each type of finish, in addition to patching completed under the requirements of Section 03300.
- B Water in patching mortar mix shall be kept to a minimum. Mortar shall be re-tempered without adding water and shall be allowed to stand for one hour prior to use, during which time it shall be mixed to prevent setting.
- C The perimeter of the hole to be repaired shall be chipped to produce sharp edges perpendicular to the face and to produce a hole not less than 30 mm deep and loose and weak material at the bottom of the hole shall be removed.
- D Just prior to placing the mortar, the hole and an area 150 mm wide entirely around it shall be wetted using clean clear water. Mortar shall be thoroughly compacted into place and screeded so as to leave the patch slightly higher than surrounding surfaces. Where the depth of patch exceeds 25 mm, the hole shall be filled to 25 mm from face and after mortar has completed 90 percent of its shrinkage, the filling of the hole shall be completed to slightly higher than surrounding surfaces.

- E The mortar shall be left undisturbed for one to two hours to permit initial shrinkage, and finished to match the adjoining work.
- F Holes left by the withdrawals of cone-ties, and/or associated tie-rods shall be filled solid with mortar. For holes passing entirely through the wall, a plunger-type grease gun or other device to force mortar through the wall, starting at the back face shall be used. Voids left by cone-tie ends shall be filled solid up to a distance of 15 mm from the face of the concrete and tamped smooth with approved tool.
- G Plain rod-tie holes shall be filled as specified above for cone-tie holes except that mortar shall be struck flush with the face of the concrete wall. Mortar smearing onto the concrete face shall then be wiped off clean with clean wet clothes or sponges.

### **3.02 Sandblasting Concrete**

- A Immediately after removal of forms, all fins and other projections shall be removed including those with adjacent surfaces. All voids, honeycombs, and air pockets greater than 17 mm in any dimension shall be patched. In areas where concentration of voids 13 mm and less occur, patch appearance across the entire surface.
- B Sandblasting shall be done after all concrete to be blasted has attained its full strength as determined by field control cubes, or after a minimum of seven days, whichever is first. Rounding edges shall be avoided. Abrasive blasting shall be carried out to the same depth and produce the same texture as the accepted sample panel, throughout, which shall conform to the medium degree of finish defined by ACI-303. As far as is practicable all concrete surfaces to be sandblasted shall have been cast for the same period, thus ensuring uniformity of finish. Voids greater than 10 mm in any dimension exposed by sandblasting shall be patched as specified above. After patches have cured and attained full strength, they shall be re-blasted until the patched areas match adjacent areas.

### **3.03 Finishes**

All voids and honeycombs over 10 mm in largest dimension and all tie rod holes and depressions shall be thoroughly patched. In areas where concentrations of small voids occur, a sufficient number of them shall be patched to produce a uniform appearance across the entire panel. Projections and fins shall be smoothed out with wet carborundum stones or power grinders to extent as directed by the Engineer. All surfaces indicated to produce a "light abrasive blast finish" shall be sandblasted. Blasting shall remove the surface skin sufficiently to expose the coarse particles of the fine aggregate as well as a few particles of the coarse aggregate in accordance with approved samples. The surface shall be flat with little texture. Light sand blasting shall be done a minimum of seven days after casting, and prior to 50 days after casting.

### **3.04 Clean-up**

Grit remaining from sandblasting shall be collected and removed frequently to an approved waste storage facility as the work progresses.

**End of Section 03800**

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## 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**

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## 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/m<sup>3</sup> 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 <sub>3</sub> ) % 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 <sub>3</sub> ) % 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 <sub>3</sub>          | 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 2<sup>1</sup>/<sub>4</sub> 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/m<sup>3</sup>
- 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/mm<sup>2</sup> with

minimum individual strength not less than 7 N/mm<sup>2</sup> 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/mm<sup>2</sup> 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/cm<sup>2</sup>. 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 3<sup>1</sup>/<sub>2</sub> 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/m<sup>2</sup> 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/m<sup>2</sup> 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. Tothing 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 of 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 expanded faces of concrete masonry units shall be removed.

**End of Section 04220**

## Section 04400

### Stone

#### 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:

- 1 Marble/granite wall cladding
- 2 Marble/granite flooring
- 3 Marble/granite in staircases, skirtings, vanity units etc.

##### 1.02 Qualifications

- A The work in this Section shall be executed by an approved specialist Sub-Contractor.
- B The fabricator shall be a firm with a minimum of five years successful experience in the fabrication of stonework units of similar sizes, shapes and finishes to the units required for this Project. The fabricator shall have ample production facilities to produce, furnish and supply the units as required for installation without delay to the Work.
- C The erector shall be a firm with a minimum of five years experience in the successful erection of stonework units of similar sizes and shapes and of similar quantities to the units required for this Project.

##### 1.03 Submittals

- A Shop Drawings:
  - 1 shop drawings of stonework showing in detail the layout, jointing, anchors and dowels, dimensions, sizes and locations of cut-outs, adjoining work, etc.
  - 2 each piece on the shop drawings shall correspond to the identification number on the back of each stone
  - 3 co-ordinate all components which are specified elsewhere (flashing, insulation, sealants) which comprise the system into this submittal
  - 4 co-ordinate shop drawings with all related trades.
- B Samples:
  - 1 600 x 600 mm samples of each type and finish of marble and granite required, showing the full range of colour and texture expected in the finished work,
  - 2 in addition submit one full size sample of each type and finish, falling in the average colour and texture range,
  - 3 Engineer's review and approval of samples shall be for colour, texture and pattern only,
  - 4 compliance with all other requirements is the exclusive responsibility of the Contractor,
  - 5 sample review and approval shall precede mock-up installations as hereinafter specified,
  - 6 provide also 400 x 400 mm stone sample panels with central cross joint to show sealant materials for the Engineer's review and selection of jointing materials.
- C Manufacturer's data sheet or equivalent printed literature indicating product information correlated to specified requirements.

- D Test Reports and Calculations:
- 1 reports of testing and inspection of anchor plugs and fasteners.
    - a provide manufacturer's test data for concrete inserts showing that the proposed inserts meet or exceed specified performance criteria.
    - b provide manufacturer's certification stating that these inserts are appropriate for the intended purpose.
  - 2 calculations, certified by a licensed professional engineer for structural adequacy of stones and anchorage system, including support of window wall in areas where stonework supports the window wall.
  - 3 reports of stone panel testing.
- E Certification. After review of samples by Engineer and prior to fabrication certify in writing and submit any additional evidence required indicating that a sufficient quantity of materials within the range of approved mock-up materials is available from a single quarry, for each specified or approved stone to satisfy the total requirements of the project.
- F Maintenance Instructions. Submit to the Engineer recommended cleaning and maintenance instructions for the marble materials being provided.

#### 1.04 Performance Criteria

Design, fabricate and install the stonework and anchorage systems to support the gravity loads and to withstand the specified inward and outward pressures normal to the wall plane. Stone breakage, anchorage failure or displacement, either from the stone or from the support system, shall not occur under loading equal to 2.5 times the design load pressures, positive and negative.

#### 1.05 Testing

- A Stone Testing Programme: The initial testing of stone will be performed prior to all other testing programmes. Samples of sizes and shapes of stone shall be provided as required for the following tests:

<b><u>Physical Property</u></b>	<b><u>Test Method</u></b>	<b><u>No. of Tests</u></b>
a. Compressive Strength	ASTM C 170	4
b. Modulus of Rupture	ASTM C 99	
Tested Dry		30
Tested Wet		30
c. Flexural Bending	ASTM C 880	
Tested Dry		30
Tested Wet		30
d. Density	ASTM C 97	2
e. Absorption		
(% by weight)	ASTM C 97	2
f. Petrographic Analysis	ASTM C 295	1

- 3 above samples shall be taken at random locations from areas which will be quarried for the project.
  - a do not take all the samples from a single block.
  - b identify and transmit a record of the samples and quarry locations from which they were taken.
- 4 based on the properties of stone as determined by the above test programme, the Engineer may revise the design safety factor as specified.

- B Stone Panel Tests:

- 1 in a certified testing laboratory acceptable to the Engineer, test three, full sized stone panels and their anchors under gravity loads and uniform loads in 50 kg/m<sup>2</sup> increments, alternately inward and outward to simulate wind loads,
  - 2 stone panels and anchors shall be representative of the sizes and shapes as proposed for the installation and the assembly shall be tested to failure and the test pressure recorded at failure. The type of failure shall be recorded i.e. anchor pull-out or stone breakage, whether pressure was positive or negative and any other pertinent information. Prior to testing, the Contractor shall submit for acceptance a description of the test assembly (including pertinent data on materials), test apparatus and procedures.
- C Welding. Provide visual inspection for 100 percent of welds, reporting on defects and measures taken to correct those defects.

### **1.06 Mock-Ups**

Following approval of sample slabs construct mock ups as follows:

- 1 wall cladding: assemble to simulate final condition, direction of graining and indicating joint conditions, use of spacers, shims, anchorage, relieving angles, supports and all other features of the final work. Erect wall mock-up adequately reinforced and braced to sustain the imposed loads. Build in all items of anchorage and support.
- 2 flooring: provide in place sample installations of flooring/skirting, etc., at locations shown or directed by the Engineer, of each type of marble work shown and specified. Each sample installation shall consist of a full pattern and shall be complete with all anchors, bedding, jointing, sealers, etc., as shown and in accordance with final shop drawings. Sample installations shall be reviewed by the Engineer for acceptance of marble and granite colour, finish, jointing, pointing and general workmanship. Replace unsatisfactory work as directed for final acceptance. Maintain sample installations during construction as a standard for judging acceptability of marble work. Properly finished and maintained sample installations may be retained as a portion of the completed work.
- 3 provide mock-up for any other stone work as shown on the drawings and as required by the Engineer.

### **1.07 Pre-Installation Co-Ordination**

- A Pre-Installation Conference: prior to the start of marble and granite installations meet at the Site and review the installation procedures and co-ordination with other Work. The meeting shall include Contractor, Sub-Contractor, and Engineer as well as others whose work must be co-ordinated with the marble work.
- B Pre-Installation Inspection:
- 1 examine all parts of the supporting Structure and the conditions under which the marble and granite work is to be installed,
  - 2 notify the Engineer in writing of any conditions detrimental to the proper and timely completion of the work,
  - 3 do not proceed with marble installation work until all unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

### **1.08 Delivery, Storage And Handling**

- A Carefully pack and load marble and granite for shipment and take necessary precautions against damage in transit. Deliver marble and granite to project site using protection and

handling equipment which will ensure that there will be no leakage, chipping, soiling, staining, discoloration, warpage, or other damage. Store above grade on wood dunnage or other suitable surfaces using polyethylene film to separate marble from wood or other supporting or protecting members. Protect from weather, soiling and damage of every kind.

- B Deliver other materials, except bulk materials, to project site in manufacturer's unopened containers with name, brand, type, grade and colour fully indicated thereon. Store bulk materials as required to avoid any deleterious effects of weather, soiling or contamination.

## Part 2 - Products

### 2.01 Materials

- A Stonework:
- 1 General:
    - a Stone shall be sound and free from defects which would impair strength, durability or appearance.
    - b Each species of stone shall be provided from a single quarry.
    - c Quarries and fabrication plants shall be available for inspection by the Engineer.
  - 2 Stone Types:
    - a all stone shall be of soundness (hardness and density), texture, graining colour tone and range matching the approved sample available for inspection in the office of the Engineer's Representative,
    - b stone flooring shall be 20 mm thick of either Verde Issoire or Chan Gree with polished finish,
    - c wall linings shall be 20 mm thick, mechanically fixed,
    - d staircase finishes shall be marble, as shown, unless it is terrazo or other finish,
    - e vanity units shall be granite 25 mm thick,
    - f facing to fountains shall be granite, generally with etched finish but polished where in contact with water, all as shown on the Drawings.
- B White Portland Cement: ASTM C 150, Type I or BS 12 non-staining in accordance with the definition and test requirements of ASTM C 91.
- C Hydrated lime: ASTM C 207, Type S.
- D Sand: pure silica sand.
- E Shrinkage reducing accelerator: "Sika Set" (Sika Corp.), or equal.
- F Mineral colouring admixture: finely ground, synthetic, lime-proof, non-fading mineral oxides having purity of 98 percent; maximum 5 percent of cement by weight.
- G Water: clear and free of deleterious material.
- H Anchorage Devices:
- 1 anchors, dowels, cramps, plug anchors, angles, relieving anchors:
    - a fabricated of stainless steel complying with ASTM A 167, Type 304.
    - b thickness as required to sustain imposed loads but not less than 5 mm.
  - 2 Devices embedded in concrete or masonry:
    - a wedge inserts with tee-shaped wedge-action slot, with askew head bolt, washer and nut;
    - b dovetail anchor slots of size to receive specified anchor, filled with waterproof filler and open face sealed;



- c adjustable insert with square nut sliding in integral track;
  - d malleable iron castings or steel fabrications, thickness as required to sustain imposed loads but not less than 5 mm.
  - e all products galvanized after fabrication.
- I Galvanising:
- 1 ASTM A 153 for galvanising iron and steel hardware.
  - 2 ASTM A 123 for galvanising rolled, pressed and forged steel shapes, plates, bars and strip 3 mm thick and heavier.
  - 3 ASTM A 386 for galvanising assembled steel products.
- J Dielectric separator: bituminous paint, "Bitumastic 50" (Koppers Co., Inc.) or "Jennite J-16" (Maintenance Coatings Co.)
- K Cushions: clear plastic and 50 Durometer neoprene 25 x 50 mm by thickness required.
- L Reinforcing mesh: chicken wire.
- M Sealant: as specified in Section 07920 - "Sealants".
- N Joint Filler: compressible joint filler as shown and as specified in Section 07910.
- O Waterproofing additive to setting bed: liquid latex additive No. 3701 (Laticrete International).
- P Tile Adhesive: epoxy adhesive complying with ANSI A136.1 and as recommended by the stone supplier.
- Q Divider Strips: complying with ASTM A 167-82 size as shown and finish as approved by the Engineer.
- R Structural Steel Shapes: complying with ASTM A 36, hot dip galvanized after fabrication where shown.
- S Non-Slip Inserts: as shown and finish as approved by the Engineer.

## 2.02 Mixes

- A Mix mortar in small batches, to a stiff plastic mass, until thoroughly homogeneous.
- 1 do not use mortar until it has set for one hour.
  - 2 mortar may be used only up to two hours after mixing.
  - 3 do not reuse mortar or use partially set mortar.
- B Mortar for Setting Stone:
- 1 one part white Portland cement, one part hydrated lime, five parts sand.
  - 2 provide waterproof additive for wet areas and exterior stone.
  - 3 prepare mortar with a shrinkage reducing accelerator diluted with water in the ratio as recommended by the manufacturer.
- C Mortar for Setting Stone Flooring Steps and Treads:
- 1 one part white Portland cement, four parts sand,
  - 2 mix as dry as can be worked,
  - 3 provide waterproofing additive for wet area flooring.

**D Pointing Mortar:**

- 1 one part white Portland cement, two parts sand, mineral colouring admixture as required to match stone,
- 2 mixed as dry as can be worked,
- 3 provide waterproof admixture for exterior and wet area pointing.

**2.03 Fabrication**

**A** Accurately cut, dress, drill, fit and finish stonework to shapes and dimensions shown on drawings and approved shop-drawings. Make exposed plane surfaces true in line and exposed curved surfaces true in radius. Thicknesses of stone shown are minimum. Any deviation below the minimum thicknesses will cause rejection and replacement of those stone panels.

**B Wall Facings:**

- 1 Cut exposed external corners of stone as shown and ease expose external edges where shown. Cut all other joints and edges square and at right angles to face, and with backs parallel to face. Make arrises straight, sharp, true, and continuous at joints. Cut and drill stones in shop as required for supports, anchors, ties and other inserts.
- 2 Allow for expansion and contraction within the limits of the joint material when cutting for anchorage devices.
- 3 Provide greater stone thickness than indicated where thicknesses indicated are insufficient for the sizes; extent of cutouts show decreased effective strength of the remaining material; for proper and sufficient anchorage; or to provide suitable and adequate bearing areas or surfaces.

**C Jambs, Heads, etc.:**

- 1 fabricate units designated for one piece installations like heads, jambs, etc., accurately to shape and sizes established by actual site measurements,
- 2 fabricate units neatly for proper installation.

**D Steps, etc:**

- 1 Cut steps, etc. to shapes and profiles shown,
- 2 make arrises straight and true and ease edges slightly,
- 3 cut and trim stone in the shop as required for supports, anchors and other inserts.

**E Flooring:**

- 1 cut stones into sizes and shapes as shown,
- 2 cut with right angle edges normal to the face plane to provide for even jointing and with back of stone roughly parallel with face plane.

**Part 3 - Execution****3.01 Condition of Surfaces**

**A** Prior to installation examine surfaces to receive stone and do not proceed until any defects detrimental to the finished work are corrected and moisture protection, structural supports, provisions for expansion, or any other condition which might affect the finished work in appearance, water tightness or integrity of the completed installation are finalised.

**B** Verify all measurements and dimensions, co-ordinate the installation of inserts for this work and co-ordinate and schedule this work with the work of other trades. Give particular attention to the location and size of cutouts required to accommodate

mechanical, electrical, and other work or adjoining construction, in accordance with the reviewed shop drawings for such trade.

- C Co-ordinate shop drawings of items or assemblies related to the support or anchorage of stonework, including requirements for clearances for proper installation.

### 3.02 Installation

- A furnish dovetail anchor slots, wedge type inserts and other items requiring building in to concrete or masonry work, along with location drawings, in sufficient time so as not to delay job progress. Inserts shall be tied with wire into reinforcing to prevent displacement. No forced entry type anchorage devices will be allowed.
- B Stone setting, anchoring, and pointing shall be in accordance with applicable requirements of specifications of the Marble Institute of America unless otherwise specified or shown.
- C Set stone in accordance with approved shop drawings, level, plumb, square, and true with uniform joints, accurately aligned with grain running in the direction shown and match work to mock-up.
- D After all adjustments have been made to stonework anchorage devices, weld adjustable supports so as to prevent future displacement or movement. All welds will be subject to visual inspection.
- E The quality of field cutting shall be the same as for shop cutting.
- F Provide dowels, anchors and ties in sufficient quantity to eliminate "rattle" or loose pieces and to ensure a rigid installation. Extent of anchorage and installation details shown are intended to indicate minimum requirements. In general, a minimum of one anchor per 0.18 sq. meter of area is required, with additional anchorage provided where necessitated by size, thickness, setting or shape.
- G Provide steel back-up support for stone work where shown on the Drawings and wherever required, particularly at lintel soffits etc., to provide rigid installation. Anchor steel support framing securely to building structure.
- H Wall Cladding:
  - 1 set relieving angles as required for proper support of stone, before setting, clean stone and backing and before setting in mortar saturate with water,
  - 2 set stone with two fixations per stone in every horizontal joint, extending full depth of stone and to within the dimension from the face as shown. Secure with anchors, dowels, cramps etc., as required for rigid and secure installation and fill anchorage holes with accelerated setting mortar. Rigidly secure strap anchors to the backing,
  - 3 repair flashing materials to their original condition where they have been punctured by anchorage or damaged during setting,
  - 4 fill the cavities behind facing with 1:4 cement sand mortar, unless full mechanical installations are called for on the drawings.
  - 5 fill and seal joints as shown.
- I Paving and Flooring:
  - 1 provide reinforcing mesh in setting bed,
    - a tamp stone into setting bed with mallet until firmly bedded to the proper level,

- b remove stone and back parge with wet cement or sprinkle the bed with water and cement after wetting the back of the stone,
  - c return to position on setting bed,
  - d use cushions and spacers to maintain uniform jointing and setting.
- 2 grout with water and neat cement by buttering the edges of the stone as they are laid. Immediately clean surplus joint cement from face of the stone,
  - 3 where grinding is required to completely align and level joints, permit a minimum of six days of setting time to elapse before commencing. Perform grinding by wet abrasion, in a manner as to retain the finish, to match the balance of stone paving, and to be free of depressions and grind marks. Exercise care to avoid damage or soiling of adjacent work.

J Erection shall comply with the following maximum non-cumulative tolerances:

- 1 variation from plumb : +/- 3 mm in storey height
- 2 variation from level : +/- 3 mm in any bay
- 3 variation in location : +/- 6 mm in any bay
- 4 edge alignment : 1.5 mm

K Joint Widths. Provide stone work joint widths as shown.

### 3.03 Protection

After initial cleaning, provide non-staining temporary wood guards at corners and other surfaces subject to damage. Rope off flooring to permit curing of setting bed and protect work from damage due to subsequent building operations. Immediately prior to completion of the Work clean stone by washing with water and bristle brushes. Remove all stains, dirt and other discolorations but do not use acids, cleaning compounds or wire brushes. On completion of construction, remove all temporary protection.

### 3.04 Engineer's Approval

Installed units which are chipped, cracked, or otherwise damaged or which, in the opinion of the Engineer, do not conform to the Specification requirements shall be removed and replaced such that the completed work meets the entire satisfaction of the Engineer.

**End of Section 04400**

## Section 05120

### Structural Steel

#### 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 Structural Steelwork.

##### 1.02 Qualifications

Structural steel fabrication and erection shall be performed by an organization experienced in structural steel work of equivalent magnitude with minimum five years documented experience. The Contractor shall verify all measurements and shall take all field measurements necessary before fabrication. The Contractor shall be responsible for correctness of detailing, fabrication, and for the correct fitting of structural members. Substitution of sections, or modification of connection details, or both, will not be accepted by the Engineer. Connections, fully designed and detailed on the Drawings, shall be furnished as shown. Members and connections, for any part of the structure, not shown on the Drawings shall be the Contractor's responsibility. Such connections shall be considered standard and designed and detailed in accordance with AISC M016. AISC S335 shall govern the work, high-strength bolting shall be in accordance with the AISC S329 and welding shall be in accordance with AWS D1.1.

##### 1.03 Submittals

###### A Shop Drawings

- 1 shop drawings shall include structural calculations for all structural steel components and their connections, all in accordance with the requirements of the Contract Documents and show the following:
  - a fabrication drawings which show type of material, size and weight of members, information for shop assembly of members of the structure and other information necessary for the fabrication of each member,
  - b drawings shall include the type, size, location and extent of all welds and bolts,
  - c drawings shall clearly distinguish between shop and field, bolts and welds,
  - d field assembly and erection drawings which show all field assembly prior to erection and after erection,
  - e drawings shall indicate all details, schedules, procedures and diagrams showing field assembly and sequence of erection,
  - f information shall indicate locations of bracing and shoring and how shoring is stabilized and controlled,
  - g drawings shall indicate elevations of shored points and splice locations,
  - h procedures shall indicate step by step erection sequences including intermediate surveys and allowances for temperature,
  - i diagrams shall indicate erection equipment, size and weight and additional elements which may be required to support or stabilize elements during erection.
- 2 written procedures for fabrication of the steel work shall describe the complete welding process including machine, current, voltage, preheat, filler metal, welding system (manual, semi-automatic or automatic), positions of welding, number of passes for each weld size, preparation of surfaces prior to welding, etc. These

- procedures shall indicate the Contractor's quality control measures, monitoring and repair procedures.
- 3 the Contractor shall be responsible for all details along with calculations to the Engineer prior to fabrication and the arrangement of all joints and their load carrying capacities. Connections may, or may not, be shown on the Drawings.
- B Manufacturer's Literature**
- 1 manufacturer's specifications and installation instructions for the following products, shall include laboratory test reports and such other data to show compliance with these Specifications (including specified standards):
    - a structural steel, (each type) including certified copies of mill reports covering: chemical and physical properties; country and rolling mill of origin; statement indicating that the steel is new billet steel; and that testing has been performed in accordance with ASTM standards,
    - b high strength bolts (each type) including nuts and washers,
    - c welding electrodes (each type),
    - d shop coat primer paint, field touch-up paint, and color samples of all paint to be used,
    - e epoxy paint,
    - f bearing materials or assemblies.
- C Testing Reports.** The following reports shall be submitted in triplicate directly to the Engineer by the testing laboratory, with copy to the Contractor.
- 1 shop welders certification.
  - 2 field welders certification.
  - 3 magnetic particle tests: shop welds and field welds.
  - 4 ultra-sonic tests: shop welds and field welds.
  - 5 high strength bolted connection tests: shop and field.

#### **1.04 Testing**

- A** The Contractor shall engage, at his own expense, an independent certified testing laboratory approved by the Engineer to inspect high strength bolted connections and welds and to perform all tests and submit test reports to Engineer as herein specified. The Contractor shall submit evidence regarding qualification of the proposed Testing Laboratory.
- B** The Contractor shall provide the testing laboratory with a complete set of shop, fabrication and erection drawings and cutting lists, order sheets, material bills, shipping bills and mill test reports. Certified copies of mill test reports shall be provided for bolts, nuts and washers including names and locations of mills and shops and analyses of chemical and physical properties, and information as to time and place of all rolling and shipment of material to shops. The Contractor shall provide representative sample pieces requested for testing, full and ample means and assistance for testing all material and proper facilities, including scaffolding, temporary work platforms, hoisting facilities, etc., for inspection of the work in the mills, shop and field.
- C** Bolted connections shall be inspected by the testing laboratory in accordance with AISC Specifications for "Structural Joints Using ASTM A325-83C, ASTM A325M-83 and ASTM A490-83A or ASTM A490-82.
- D** Welding shall be inspected and tested by the testing laboratory during fabrication and erection of structural steel as follows:
- 1 certify all welders in accordance with AWS and make inspections and tests as

- required. Record types and locations of all defects found in the work, and measures required and performed to correct such defects,
- 2 in addition to visual inspection of all welds, magnetic particle and ultra-sonic inspection shall be made of all welds indicated on the Drawings. Magnetic particle inspection shall be made on the root pass and finished weld,
  - 3 the method of magnetic particle inspection shall be in accordance with ASTM E109. Any type of crack or zone of incomplete fusion or penetration will not be acceptable,
  - 4 ultra-sonic inspection shall be performed in accordance with AWS D1.1.
- F Each bolting crew and welder shall be assigned an identifying symbol or mark. All shop and field connections shall be so identified so that the inspector can refer back to the crew or person making the connection.
- G The testing laboratory shall be responsible for conducting and interpreting the tests, shall state in each report whether, or not, the test specimens conform to all requirements of the Contract Documents and any deviations therefrom.
- H Access to places where material for this Contract is being fabricated or produced shall be provided to Engineer and the testing laboratory for the purpose of inspection and testing. The Engineer and the testing laboratory may inspect structural steel at the plant before shipment. The Engineer reserves the right to reject any material, at any time before final acceptance, which does not conform to all of the requirements of the Drawings and Specifications. The testing laboratory shall perform specified tests and submit reports to the Engineer. Any corrective measures, including additional and more complete testing, which may result from these tests shall be the Contractor's responsibility. The Contractor shall pay for all costs of above.
- I The Contractor shall coordinate and allow for necessary time for the testing laboratory to complete all testing and inspections prior to shop painting.
- J The testing laboratory shall prepare test specimens from steel samples cut from delivered material and shall conduct tension tests in accordance with ASTM. To provide the steel for testing the Contractor shall order one metre extra length for the members noted on the Drawings.

### **1.05 Substitutions**

- A The Contractor shall fabricate and erect the structural steelwork as shown on the Drawings and Specifications. Details of all fabrication and construction shall be submitted to Engineer for approval.
- B All changes and modifications require that the Contractor shall guarantee, in writing, signed by a principal officer of the company, that the equipment offered will provide comparable or superior features to the equipment specified including performance; quality; materials of construction.
- C Costs of any changes incidental to the installation of the alternate equipment such as electrical wiring, relocation of piping, engineering supervision, ductwork, building configuration and design, shall be at the expense of the Contractor with no additional expense to the Employer.
- D If, after installation, the alternate installation does not perform in accordance with the specifications, or other deficiencies are noted, the Employer will require the modification

or replacement of such equipment to meet the specifications at no additional expense to the Employer.

### 1.06 Delivery, Storage and Handling

- A Care shall be exercised to avoid abrasions and other damage and structural steel shall not be handled until paint has thoroughly dried.
- B Storage of fabricated steel at the job site shall be the responsibility of the Contractor. Material shall be stacked above ground out of mud and dirt and provided for proper drainage and protected from damage or soiling by adjacent construction operations. Material stored at the job site shall not exceed design loads on existing or newly-constructed structures so that members will not be distorted or otherwise damaged and shall be protected against corrosion or deterioration.
- C Material shall not be delivered to the project site until the proposed method and sequence of erection has been reviewed by the Engineer. The method and sequence shall be planned so as to avoid delay or damage to the work of other trades.

## Part 2 Products

### 2.01 Structural Steelwork

All structural steel shall conform to ASTM A43 Grade 36 (min. yield strength 300 N/mm<sup>2</sup> unless noted otherwise). All bolts, nuts and washers shall conform to the requirements of ASTM A490 and A325. All bolts shall be cold forged with rolled threads. All structural testing shall conform to ASTM A 500, Grade B, Seamless, yield stress 317 N/mm<sup>2</sup>.

### 2.02 Welding Electrodes

All welding electrodes shall be E70XX and shall comply with the provisions of AWS Specifications A5.1, A5.5, A5.17, A5.18, A5.20. All welds not specified shall be continuous fillet welds using not less than the minimum size based on thickness of the thicker part jointed.

Thickness	Min. Weld Size
12 mm	4 mm
Over 12 mm to 20 mm	6 mm
Over 20 mm to 40 mm	8 mm
Over 40 mm to 50 mm	10 mm

### 2.03 Grout

Grout shall be in accordance with Section 03600, and manufacturer's recommendations.

### 2.04 Paint

- A Primers: steel surfaces, which are not embedded in concrete, shall be painted with anti-corrosive primer complying with BS 5493. Minimum dry film thickness 50 microns for all members that will receive finishing coat. All other members/surfaces will receive three coats of total thickness 150 microns.
- B Finishing Coat: all steel members exposed to view shall be coated in accordance with Section 09870.



- C Use spray application for painting and minimum thicknesses shall be maintained on all corners, edges and ends of pieces. Surface to be painted shall be dry and above 2°C and temperature of the air shall be over 5°C. No painting shall be undertaken outdoors in rainy and dusty weather and at least 24 hours drying time in good weather shall be allowed before re-coating.

## 2.05 Source Quality Control

- A Testing and inspection of structural steel will be performed by an independent structural steel testing agency engaged by the Contractor, at his own expense and approved by the Engineer. The testing agency shall be provided with the following:
- 1 a complete set of accepted documents required under "Submittals",
  - 2 cutting lists, order sheets, materials bills and shipping bills,
  - 3 information as to time and place of all rollings and shipments of materials to shops,
  - 4 representative sample pieces as requested by the testing agency,
  - 5 full and ample means and assistance for testing all material,
  - 6 proper facilities, including scaffolding, temporary work platforms, etc., for inspection of the work in the mills, shop and field.
- B The Inspector will perform his duties in such a way that fabrication and erection are not unnecessarily delayed or impeded, and as follows:
- 1 the Inspector will make all tests and inspections as required by "Structural Welding Code",
  - 2 the edges of material to be welded will be ultrasonically examined for evidence of laminations, inclusions or other discontinuities. The extent to which such defects will be permitted and the extent of repair permitted shall be determined by the Inspector and made in accordance with ASTM A6, Paragraph 9. Repairs made by welding shall be done in compliance with the requirements of AWS D1.1 and the accepted welding procedures,
  - 3 the root layer of all multiple pass welds and the backside of groove welds made from both sides, after back gouging or chipping, will be examined by magnetic particle inspection (or dye penetration if magnetic particle inspection is not feasible).
  - 4 all shop and field welds shall be listed as stated on Drawings,
  - 5 the technique of radiographic inspection will be in accordance with the requirements of AWS D1.1. A double film technique will be used. One copy of each film will be sent to the Engineer, the other will be retained by the Inspector,
  - 6 where inspection reveals defects, the extent of inspection will be increased as much as necessary to ensure that full extent of the defects in a joint has been found and that the same defects are not present in welds made on similar parts or under similar circumstances,
  - 7 work that is not acceptable will be designated by "Repair" or "Reject", as applicable,
  - 8 shop welds will be inspected in the shop before the work painted or approved for shipment,
  - 9 the Inspector will maintain a daily record of the work he has inspected and its disposition. Reports of tests will be made in form prescribed in AWS D1.1. One copy of each of the reports will be submitted to the Engineer on a weekly basis,
  - 10 the Inspector will make all tests and inspections of high strength bolt connections as required by AISC S314.

## **Part 3 Execution**

### **3.01 Bench Marks**

The Contractor shall employ the services of a registered professional engineer who shall establish permanent bench marks, field check all elevations of concrete on which structural steel is to be placed, locate anchor bolts, report discrepancies to the Engineer, and obtain the Engineer's approval before the work proceeds.

### **3.02 Erection**

- A The Contractor shall be responsible for the accurate setting and leveling of all bearing plates or setting plates. Bearing plates or setting plates shall be leveled on steel wedges or shims, or as otherwise detailed, and shall be grouted as specified. Templates shall be furnished for accurate setting of all anchor bolts. Shim plates or fills shall be provided where required to obtain proper fit and alignment.
- B Oxygen cutting of structural steel in excess of 3mm for "fitting-up" purposes shall not be done except with the prior approval of to the Engineer. The use of an oxygen cutting torch for correcting fabrication errors will be permitted only when the member is not under load, and only after prior written approval of the Engineer to the procedures to be followed in the event corrective work is necessary.

### **3.03 Erection Tolerance**

- A The Contractor shall be responsible for the correct fitting of all structural members and for the elevation and alignment of the finished structure. Any adjustments necessary in the steelwork because of discrepancies in elevations and alignment shall be the responsibility of the Contractor.
- B Unless otherwise noted, the structure shall be leveled and plumbed to an accuracy of 1 to 1000, but not to exceed 12 mm. The actual centerlines of truss chords shall not vary from theoretical centerlines by more than 12 mm at any point. The difference between offsets to the actual centerlines of truss chords at adjacent panel points shall not exceed 3mm. All leveling and plumbing shall be done based on the mean operating temperature of the structure. Allowances shall be made for the difference in temperature at time of erection and the mean temperature at which the structure will be when completed and in service.
- C All measurements relating to the above shall be on the theoretical centerlines of the members.

### **3.04 Connections**

- A Welding or bolting shall not be performed until all stiffening components of the structure have been properly aligned.
- B Drift pins shall not be used to enlarge holes in primary members. Holes that must be enlarged to admit bolts shall be reamed. Burning and drifting may be used to align holes only in secondary bracing members, and only when approved by the Engineer.
- C When high strength bolts, or high strength bearing bolts, are used, the AISC specifications shall apply, including values as noted therein, and installation shall be with torque wrenches. In using manual torque wrenches, the required torque can be read from

the wrench dial but care should be taken that the wrench is properly calibrated. Nuts shall be in motion when torque is measured. In using power wrenches, the recommendations of the wrench manufacturer shall be followed. Hardened washers shall be used under bolt head or nut whichever is turned in tightening, unless the specified standards require hardened washer under both head and nut.

- D All bolts shall be kept in dry storage until needed for installation. A325 bolts 28mm and 32 mm diameter and A490 bolts 25 mm diameter and over shall have Johnson's Stick Wax No. 140 applied to their threads before being assembled in the work. If bolts have been left out and have become rusty before use, they shall be rejected and shall not be used until they have been cleaned and waxed with Johnson's Stick Wax No. 140.
- E Welded and bolted connections shall be tested in accordance with the requirements of 1.06, Testing, and as indicated on the Drawings.

### 3.05 Setting Bases and Bearing Plates

- A The Contractor shall clean concrete and masonry bearing surfaces of bond-reducing materials and roughen to improve bond to surfaces. The bottom surfaces of base and bearing plates shall also be cleaned.
- B Loose and attached baseplates and bearing plates for structural members shall be set on wedges or other adjusting devices.
- C The anchor bolts shall be tightened after the supported members have been positioned and plumbed. Wedges or shims shall not be removed, but, if protruding, shall be cut off flush with edge of the base or bearing plate prior to packing with grout.
- D Grout shall be packed solidly between bearing surfaces and bases or plates to ensure that no voids remain. Exposed surfaces and installed materials shall be protected and allowed to cure in strict compliance with the manufacturer's instructions, or as otherwise required.

### 3.06 Weld Test Schedule

Weld Location	Length of Weld to be Tested Specification	Type of Weld	Test	ASTM Test
Other stress Carrying Welds	300 mm in 3 m	Fillet	M.P.*	E709 (magnetic particle)
Flange Splice (Full Penetration) (Weld only)	300 mm (min. test) 100%	Groove Groove	U.T. U.T.	E164 (ultrasonic) E94 (Radio graphic)-Shop
Web Splice	Top - 100%	Groove	U.T.	E164 (ultrasonic)-Field E94 (radiographic) - Shop
Bearing Stiffener to Web	Bottom - 33% Middle - 34%	Groove	U.T.	E164 (ultrasonic)-Field
Misc. Secondary Members Tension Zones	300 mm in 1.2 m 300 mm (min. test)	Fillet	M.P.*	E709 (magnetic particle)
Compression Zones	300 mm in 3 m (min. test) Visual only	Fillet	M.P.*	E709 (Magnetic Particle)

\* Only for field welds E165, liquid penetrant test may be substituted.

### 3.07 Survey

The Contractor shall make an accurate survey of actual locations of steel members immediately upon the completion of erection of steel but before removal of shoring and shall promptly submit same to the Engineer. Should locations vary beyond the allowable tolerances, the necessary corrective measures and procedures shall be performed with approval of the Engineer. The Contractor shall survey the finally erected structural steel after release of shoring, but prior to final removal of shoring elements and prior to the start of any other work. Any discrepancies from Contract requirements shall be reported to the Engineer.

**End of Section 05120**

## Section 05500

### Miscellaneous Metals

#### Part 1 General

##### 1.01 Description

- A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with metal fabrication work.
- B Metal fabrication work is defined as including any items shown on the Drawings and/or specified herein, fabricated from steel and iron shapes, plates, bars, pipes, tubes, casting and roll-formed shapes which are not a part of an overall system specified in any other Section of these Specifications.

##### 1.02 Quality Assurance

- A Reference Standards:
  - AISC S326, Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings (referred to herein as AISC specification).
  - ANSI A14.3, Ladders-Fixed-Safety Requirements.
  - ASTM A36, Standard Specification for Structural Steel.
  - ASTM A48, Standard Specification for Gray Iron Castings.
  - ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
  - ASTM A108, Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality.
  - ASTM A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - ASTM A197, Standard Specification for Cupola Malleable Iron.
  - ASTM A307, Standard Specification Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
  - ASTM A325, Standard Specification for High-Strength Bolts for Structural Steel Joints.
  - ASTM A496, Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.
  - ASTM A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
  - ASTM A525, Standard Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
  - ASTM A536, Standard Specification for Ductile Iron Castings.
  - ASTM A563, Standard Specification for Carbon and Alloy Steel Nuts.
  - ASTM A582, Standard Specification for Free-Machining Stainless and Heat-Resisting Steel Bars, Hot-Rolled or Cold-Finished.
  - ASTM A666, Standard Specification for Austenitic Stainless Steel, Sheet, Strip, Plate, and Flat Bar.
  - ASTM A668, Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial use.
  - ASTM A780, Standard Practice for Repair of Damaged Hot-Dipped Galvanized Coatings.
  - ASTM A786, Standard Specification for Rolled Steel Floor Plate.
  - ASTM B26, Standard Specification for Aluminum-Alloy Sand Castings.
  - ASTM B36, Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar.

ASTM B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes.

ASTM B308, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Shapes.

ASTM B632, Standard Specification for Aluminum-Alloy Rolled Tread Plate.

ASTM F467, Standard Specification for Non-Ferrous Nuts for General use.

ASTM F468, Standard Specification for Non-Ferrous Bolts, Hex Cap Screws, and Studs for General Use.

ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.  
Aluminum Association (AA):

a 30-86, Specifications for Aluminum Structures.

b Standard Specifications for Highway Bridges.

### 1.03 Qualifications

The Contractor shall employ only experienced tradesmen for both fabrication and installation, who are capable of producing work of the highest standards of quality in the industry.

### 1.04 Submittals

A Manufacturer's Literature shall include specifications, load tables, dimension diagrams, anchor details and installation instructions for products to be used in the manufacture of metal fabrications, including paint products.

B Shop Drawings shall include:

- 1 shop drawings for the fabrication and erection of all assemblies of metal fabrication work which are not completely shown by manufacturers' data sheets.
- 2 include plans and elevations at not less than 1:10 scale, and include details of sections and connections at not less than 1:5 scale.
- 3 show anchorage and accessory items.
- 4 give location, type, size and extent of welding and bolted connections and clearly distinguish between shop and field connections.
- 5 prior to submittal, coordinate shop drawings with related trades to ensure proper mating of assemblies.
- 6 detailed drawings shall show material type, thickness, grade/class, dimensions, and construction scheme.
- 7 the submittal shall include catalog pages, erection description, manufacturers data/instructions and templates.

C Test Reports. The Contractor shall furnish certified physical and chemical mill test reports for materials used for major structural members.

D Samples shall include:

- 1 handrail assembly to show joints, bends, toeplate, posts and anchorage,
- 2 stair treads and safety nosings, 200 mm long,
- 3 gratings and plates, 200 x 200 mm,
- 4 fasteners and anchoring devices.

### 1.05 Delivery, Storage and Handling

Store on blocking so that no metal touches the ground and water cannot collect on the miscellaneous fabrications and protect from bending under their own weight or superimposed loads.

## Part 2 Products

### 2.01 General

- A Products and manufacturers specified herein are specified for the purpose of establishing minimum quality standards.
- B Structural steel fabrication and erection shall be performed by an organization experienced in work of equivalent magnitude.
- C The Contractor shall verify all measurements, shall take all field measurements necessary before fabrication and shall be responsible for correctness of detailing, fabrication, and for the correct fitting of structural members.
- D Substitution of sections or modification of connection details, or both, will not be accepted by the Engineer.
- E Connections fully designed and detailed on the Contract Drawings shall be furnished as shown. Members and connections, for any part of the structure, not shown on the Contract Drawings shall be the Contractor's responsibility. Such connections shall be considered standard and designed and detailed in accordance with AISC M016.
- F AISC S335 shall govern the work, high-strength bolting shall be in accordance with AISC S329 and welding shall be in accordance with AWS D1.1.

### 2.02 Materials

- A Steel
  - 1 structural steel: ASTM A36, Grade 43,
  - 2 steel pipe: ASTM A53, Types E or S, Grade B,
  - 3 structural Tubing: ASTM A500, Grade B,
  - 4 bolts, nuts and washers, high strength: ASTM A325, and unfinished: ASTM A307, Grade A. Provide two washers for each nut and bolt,
  - 5 anchor bolts: ASTM A36,
  - 6 electrodes for welding steel: AWS A5.1, E70 Series,
  - 7 steel forgings: ASTM A668.
- B Iron
  - 1 ductile iron: ASTM A536,
  - 2 gray cast iron: ASTM A48,
  - 3 malleable iron: ASTM A47, A197.
- C Stainless steel shall conform to ASTM A167 and ASTM A276 and the alloy types shall be minimum type 316 unless otherwise stated.
- D Aluminum
  - 1 rolled shapes and extrusions: ASTM B308 or B221.
  - 2 castings: ASTM B26.
  - 3 alloys 6061-T6 or 6063-T6 unless specified otherwise in this Section.
  - 4 aluminum angles, beams, pipes, plates and channels: Alloy 6061-T6.
  - 5 aluminum weir plates and baffles: Alloy 6061-T6.
  - 6 aluminum bolts: ASTM F468, alloy 2024 T4.
  - 7 aluminum nuts: ASTM F467, alloy 2024 T4.
  - 8 electrodes for welding aluminum: AWS D1.2, filler alloy 4043 or 5356.

- E Washers: same materials and alloy as found in accompanying bolts and nuts.
- F Galvanizing
  - 1 iron and steel: galvanizing shall be done in accordance with ASTM A123 with an average coating weight of 600 g/m<sup>2</sup> and not less than 560 g/m<sup>2</sup>,
  - 2 ferrous Metal Hardware Items. These shall be galvanized in accordance with ASTM A153 with an average coating weight of 400 g/m<sup>2</sup>,
  - 3 touch-up material for galvanized coatings: galvanized coatings marred or damaged during erection or fabrication shall be repaired in accordance with the coating manufacturer's instructions.
- G Expansion anchors shall be Kwik-Bolt II by Hilti, Red Head by Phillips Drill Co., or approved equal and shall meet or exceed ICBO requirements.
- H Adhesive anchors shall be HVA anchors by Hilti or approved equal and shall meet or exceed ICBO requirements.
- I Headed studs shall be to ASTM A108 with a minimum yield strength of 345N/mm<sup>2</sup> and minimum tensile strength of 414N/mm<sup>2</sup>.
- J Deformed bar anchors shall be to ASTM A496 with a minimum tensile strength of 552 N/mm<sup>2</sup> and a minimum yield strength of 483 N/mm<sup>2</sup>.

### 2.03 Manufactured Units

- A Ladders
  - 1 material: stainless steel ASTM, type 316, Grade A or galvanized steel as scheduled, or aluminium, Grade 6082 (HE - 30) to BSEN 515 & BSEN 754 as indicated,
  - 2 rails: minimum sizes as detailed on Drawings,
  - 3 minimum distance from centerline of rungs to wall: 200 mm,
  - 4 rung spacing: uniform, maximum 300 mm and top rung level with top platform,
  - 5 design to support minimum 140 kg concentrated vertical load with 70 kg concentrated horizontal load. Maximum allowable stresses as per AISC Specification of AA specification. Maximum lateral deflection: side rail span/300,
  - 6 provide ladder cage where shown on the Drawings. Cage construction shall be as follows:
    - a hoops: minimum 6 mm x 50 mm bar,
    - b vertical bars: minimum 4 mm x 40 mm bars,
    - c all connections shall be constructed from same material as ladder,
  - 7 designed in accordance with OSHA standards and applicable codes,
  - 8 construction: fully welded type and all welds to be full penetration welds,
  - 9 ladder accessories:
    - a telescoping tubular steel section that automatically locks into place when fully extended,
    - b accessories shall be constructed from same material as ladder,
    - c corrosion-resistant spring,
    - d factory assembled with all hardware necessary for mounting to ladder where indicated on the Drawings.
- B Abrasive Stair Nosings
  - 1 two component consisting of an embedded sub-channel, installed with concrete pour, and an abrasive tread plate to be installed later,
  - 2 6063-T5 extruded aluminum, mill finished and heat-treated,



- 3 complete with concrete anchors and tread plate securing screws,
  - 4 units: 100 mm less in length than stair width.
- C Stairs - Grating: Fabricated as indicated
- 1 grating treads as specified with exception that nosing shall have integral corrugated non-slip edge,
  - 2 landings: Grating as specified,
  - 3 fabricate and design stair, landing assembly and connections to support a 450 kg concentrated, moving load or 5 kN/m<sup>2</sup> uniform live load, whichever requires the stronger component,
  - 4 fabricate and design stair components in accordance with NAAMM Metal Stairs Manual,
  - 5 design, fabricate, and install in compliance with applicable codes,
  - 6 material: aluminum alloy 6061-T6.
- D Steel Checkered Plate
- 1 conform to ASTM A786 with diamond pattern no. 3 (large) or no. 4 (medium) but only use one pattern throughout the project. The material shall have 165N/mm<sup>2</sup> minimum yield strength,
  - 2 design live load capacity unless noted otherwise, 5 kN/m<sup>2</sup> with maximum deflection of 1/300 of span under a superimposed live load of 2.5 kN/m<sup>2</sup>,
  - 3 reinforce as necessary with steel angles,
  - 4 plate sections: maximum 1000 mm wide and minimum 6 mm thick,
  - 5 provide joints at center of all openings unless shown otherwise. Reinforce joints and openings with additional angles to provide required load carrying capacity,
  - 6 unless shown otherwise, frame for opening for steel checkered plate:
    - a steel angles 40 x 40 x 6 mm minimum size having 8 mm dia x 150 mm long steel anchor bolts spaced at maximum of 600 mm OC along each side with not less than two anchor bolts per side,
    - b Drill and tap frame to receive 8 mm dia steel cap screws at not more than 600 dmm OC with not less than two screws per side,
  - 7 provide galvanized checkered plate and edge supports unless noted otherwise.
- E Aluminum Checkered Plate:
- 1 conform to ASTM B632: Diamond pattern: Use one pattern throughout project and material type 6061-T6,
  - 2 design live load capacity unless noted otherwise, 5 kN/m<sup>2</sup> with maximum deflection of 1/300 of span under a superimposed live load of 2.5 kN/m<sup>2</sup>,
  - 3 reinforce as necessary with aluminum angles,
  - 4 plate sections. maximum 1000 mm wide and minimum 6 mm thick,
  - 5 provide joints at center of all openings unless shown otherwise. Reinforce joints and openings with additional angles to provide required load carrying capacity,
  - 6 unless shown otherwise, frame for openings for aluminum checkered plate:
    - a aluminum angles 40 x 40 x 6 mm minimum size having 8 mm dia x 150 mm long steel anchor bolts spaced at maximum of 600 mm along each side with not less than two anchor bolts per side,
    - b drill and tap frame to receive 8 mm dia aluminum cap screws at not more than 600 mm OC with not less than two screws per side.
- F Aluminum Grating: Fabricate in accordance with NAAMM Metal Bar Grating Manual.
- 1 minimum depth: 38 mm,
  - 2 minimum rectangular bar size: 5 mm thick,
  - 3 minimum I-bar flange width: 6 mm,

- 4 allowable superimposed live load: Not less than 10 kN/m<sup>2</sup> with a maximum deflection of 6 mm under a superimposed live load of 5 kN/m<sup>2</sup>,
- 5 cross bars: welded, swaged or pressure locked to bearing bars,
- 6 top edges of bars: serrated,
- 7 grating sections: not wider than,
- 8 standard mill finish,
- 9 ends and perimeter edges: banded,
- 10 openings through grating: reinforced to provide required load carrying capacity and banded with 100 mm high toe plate,
- 11 provide openings at joints between individual grating sections,
- 12 clips and bolts: stainless steel.

#### G Manhole and Valve Covers and Frames

- 1 Covers and frames shall be manufactured from ductile iron complying with BS 2789 and seatings shall be designed to be non-rocking.
- 2 Castings shall be smooth, true to pattern and free from projections, sandholes, blow holes or other distortions.
- 3 They shall meet or exceed minimum wheel loading requirements as defined for the specified grade test load in accordance with BS EN 124: 1994. "Heavy duty cover" means the cover is capable of a Class D400 (BS EN 124: 1994) test load. "Medium duty cover" means the cover is capable of Class B125, (BS EN124: 1994) test load. "Light weight cover" means the cover is capable of a Class A15 (BS EN 124: 1994) test load. In general, all covers and frames used in the Works shall be heavy duty unless otherwise detailed and or directed by the Engineer and shall be single sealed with two vent holes of 5 mm. Key holes shall be of the closed type.
- 4 The frame shall be square with a minimum clear opening of 600 mm diameter or, as sized on the Drawings, and shall be fixed to the manhole shaft by four 16 mm diameter stainless steel nuts on a threaded rod in a regular pattern. The frame shall be notched to accommodate the bolts. Contact surface between cover and frame shall be greased with heavy duty grease prior to the fitting of the cover.
- 5 Covers shall have the BS no./ the grade/ manufacturer's name and name of service "WATER", "SEWER" or "STORMWATER" clearly embossed on them. Covers and frames shall be grit blasted and coated with a suitable heavy duty abrasion resistant epoxy paint to a minimum Dry Film Thickness (DFT) of 400 microns.
- 6 The Contractor shall supply one prying and lifting bar with each 20 covers (minimum of one tool for every type cover). Prying and lifting bars shall be of approved appropriate design to match the different cover configurations.
- 7 The Contractor shall furnish to the Engineer, manufacturer's certificates certifying compliance of the cover and frames to the specification.

#### H Miscellaneous Products

- 1 Grates and frames for horizontal stormwater gullies shall be made of ductile or cast iron in accordance with the requirements of BS EN124 and the dimensions given on the Drawings. Castings shall be of sound manufacture, free from voids or projections and treated with two coats of an approved rust proofing compound such as Inertol thick L or approved equal.

#### I Heavy-duty Castings, Trench Covers, and Accessories:

- 1 prefabricated, ASTM A48 or A536,
- 2 design load: AASHTO HS-20 wheel loading for indicated span,
- 3 machine horizontal mating surfaces.

#### J Step irons

- 1 material: galvanized malleable cast iron to BS 1247 or stainless steel to BS 1247.
- 2 shall be staggered 250 mm long and 150 mm wide and shall be spaced 300 mm horizontally and 225 mm vertically,
- 3 shall not be used for moving or lifting any precast rings or segments to which they are fixed.

#### **2.04 Shop Primers**

- A Primers selected shall be compatible with finish paints and in accordance with Sections 09900 and 09870.
- B Aluminum shall have mill finished unless scheduled or otherwise specified or, if approved, finished in manufacturer's standard. Coat surfaces in contact with dissimilar materials as specified in Sections 09900 and 09870.

#### **2.05 Fabrication- General**

- A For the manufacture of metal fabrications which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness. Remove such blemishes by grinding, or by welding and grinding, prior to cleaning, treating and application of finishes including zinc coatings.
- B Use materials of the size and thickness shown, of the required size and thickness to produce adequate strength, close and durability in the finished product for the intended use. Work to the dimensions shown or approved on shop drawings, using proven details of fabrication and support. Use the type of materials specified for the various components of work.
- C Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1 mm unless otherwise shown. Form bent metal corners to the smallest radius possible without causing grain separation or otherwise impairing the work.
- D Verify dimensions by accurate field measurement before fabrication wherever work adjoins other work that precedes it in construction. Allow for trimming and fitting of metal fabrication work wherever the taking of field measurements before fabrication might delay the work. On shop drawings, note which dimensions have been verified by field measurement.
- E Weld corners and seams continuously and in accordance with the recommendations of AWS. Grind exposed welds smooth and flush, to match and blend with adjoining surfaces.
- F Form exposed connections with hairline joints which are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type shown, or if not shown, use Phillips flat-head (countersunk) screws or bolts.
- G Pre-drill bolt and/or screw holes as shown and as required for attachment of metal fabrication work and for the attachment of adjacent materials prior to galvanising.
- H Furnish inserts and anchoring devices which must be set in concrete or built into masonry for the installation of metal fabrication work. Co-ordinate delivery of such devices with other work so as to avoid any delay.

- I Provide for anchorage of the type shown, co-ordinated with the supporting structure and the construction program. Fabricate and space anchoring devices as required to provide adequate support.
- J Cut, reinforce, drill and tap metal fabrication work as may be required to receive finish hardware and similar items of work.
- K Use hot-rolled steel bar for work fabricated from bar stock, except where shown or specified to be fabricated from cold-finished or cold-rolled stock.
- L Pre-assemble work at shop to the greatest extent possible, so as to minimize field splicing and assembly of units at the project site. Disassemble units only to the extent necessary to comply with shipping limitations. Mark units clearly for reassembly and proper installation.
- M Where shown as galvanized, complete the shop fabrication prior to application of the coating. Remove mill scale and rust, clean and pickle the units as required for coating. Apply hot-dip zinc coating of 0.6 kg/m<sup>2</sup> in accordance with ASTM A 123.

## 2.06 Fabrication - Specific Items

- A Miscellaneous Trim:
  - 1 provide shapes and sizes as required for the profiles shown,
  - 2 except as otherwise noted, fabricate units from structural steel shapes, plates and steel bars, with continuously welded joints and smooth exposed edges,
  - 3 use concealed field splices wherever possible,
  - 4 provide cutouts, fittings and anchorages as required for co-ordination of assembly and installation with other work.
- B Railings and Handrails:
  - 1 provide railings and handrails of designs and dimensions shown, with smooth bends and welded joints ground smooth and flush,
  - 2 comply with ANSI A12.1 and ANSI A58.1 for railings around floor openings and exposed edges of floors, stairs, ramps, etc. and similar locations,
  - 3 provide handrails on walls at stairs and similar locations as required by ANSI A12.1,
  - 4 installed railings, and supports, shall withstand a 110 Kg. load applied at any point, downward or horizontally or 75 Kg/m along the top rail, whichever is greater,
  - 5 complete with all sleeves, brackets, bolts and fastening devices as required for a complete installation.
- C Edge Angles and Seating Angles:
  - 1 provide edge angles or seating angles of size as shown on the Drawings with welded-on strap anchors 600 mm on centres,
  - 2 install angles in as long lengths as possible. Mitre and weld corners and provide splice plates for alignment between sections,
  - 3 trench covers:
    - a provide removable galvanized steel, medium duty checkered plate covers minimum of 6 mm thick with sunken handles over HT and LT trenches complete with angles, junctions, etc.,
    - b provide angle frames and anchors as required to support plate covers.
- D Duct Covers
  - 1 covers shall be manufactured by Glynwed Brick House or other equal and approved.,
  - 2 covers shall be of cast iron with concrete grade 35 in-filling unless otherwise specified,

- 3 cover and frame manufactured in 2 mm stainless steel,
- 4 shall be capable of supporting a 3000 kg wheel load,
- 5 covers shall, preferably, be single span but multi-span with intermediate beams are acceptable on larger openings,
- 6 covers and frames shall have edging strips and keyhole extensions of brass for floor finishes when provided in floors inside buildings.

E Roof and Floor Access Hatches

- 1 roof and floor access hatches shall be of approved manufacturer and shall be suitable for mounting on a concrete slab with exterior aluminum panels over the insulation,
- 2 access hatches shall be furnished and installed as shown on the Drawings and shall be aluminum unless otherwise shown on the Drawings,
- 3 locks, where required, shall be suited with the door locks,
- 4 drains shall be installed as required.

F Car Park Shade Canopies

- 1 fabricate canopies from structural steel cantilevered frames and hollow steel box section rails and purlins as indicated on the Drawings,
- 2 fix steel framework to concrete substrate with requisite fixing devices,
- 3 provide all trim as required,
- 4 shop prime the complete assembly prior to erection.

## 2.07 Shop Painting

Clean, treat and paint metal fabrications work in the shop prior to delivery to the project site, except for work which has been hot-dip galvanized after fabrication. Include all surfaces, inside and out, whether exposed or concealed in the construction.

## 2.08 Fully Concealed Items

Clean steel and wrought iron work by "Solvent Cleaning" method specified in SSPC-SP 1-63, followed by "Hand Tool Cleaning" to remove loose mill scale and rust by methods specified in SSPC-SP 2-63. Apply paint as per system A section 09870.

## 2.09 Exposed Interior Items

- A Clean and paint work which is not accessible to foot traffic, floor cleaning operations or hand contact, as specified for "Fully Concealed Work", except that mill scale and rust which would result in visible roughness must be removed and the surfaces must be made smooth before painting.
- B Apply the following cleaning, treatment and painting to interior work which is exposed (or partially exposed), and is subject to foot traffic, floor cleaning operations or hand contact by the building occupants.
- 1 clean by "solvent cleaning" method specified in SSPC-SP 1-63, followed by "hand tool cleaning" by method specified in SSPC-SP 2-63 or "power tool cleaning" by method specified in SSPC-SP 3-63 to remove loose mill scale and rust. "Pickle" by methods specified in SSPC-SP 8-63 to remove all remaining mill scale and rust. Grind rough surfaces as may be necessary to provide smooth metal surfaces. Tool cleaning and pickling may be omitted from work fabricated from cold-rolled or cold-finished stock and from castings, provided the surfaces are not heavily rusted.
  - 2 Apply pre-treatment to inhibit corrosion and improve paint adhesion, by methods specified in SSPC-PT 2-64 for "cold phosphate" treatment.

- 3 Apply prime coat of metal primer paint as soon as possible after pre-treatment. Provide a smooth coat, with uniform dry film thickness of 0.05 mm.

## **Part 3 Execution**

### **3.01 Condition of Surfaces**

Examine the substrate and conditions under which the work is to be installed. Do not proceed with the installation until satisfactory conditions have been corrected in a manner acceptable to the Engineer.

### **3.02 Installation**

- A Set metal fabrication work accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels.
- B Anchor securely as shown or as required for the intended use, using concealed anchors wherever possible. Fastenings to wooden plugs will not be permitted. Drill holes for bolts to the exact diameter of the bolt, using a rotary drill for concrete and a percussion drill for masonry.
- C Where pipe sleeves are used to support miscellaneous iron work, anchor sleeve securely to supporting concrete or structure to provide rigid support. Pipe sleeves shall be of galvanized steel of size shown and adequate to meet the requirements.
- D Fit exposed connections accurately together to form tight hairline joints.
  - 1 weld connections which are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations,
  - 2 grind joints smooth and touch up shop paint coat,
  - 3 do not weld, cut or abrade the surfaces of exterior units which have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.
- E Deliver items which are to be built into the work of other sections in time so as not to delay the progress of work.
- F Leave work exposed to view clean, smooth and neatly finished.

**End of Section 05500**

## Section 06100

### Carpentry

#### 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 rough and finished carpentry work.

##### 1.02 Requirements of Regulatory Agencies

Treat those items required by applicable codes to be treated and those items shown or specified as "Fire Retardant Treated Wood".

##### 1.03 Submittals

- A Certification of Wood Preservative Treatment shall state:
  - 1 name of preservative used,
  - 2 retention in kg/m<sup>3</sup> of lumber treated,
  - 3 treated material conforms to drying time and surface deposit requirements of FS TT-W-572.
  - 4 for water borne preservative treated materials, the moisture content after treatment does not exceed 15 percent.
  
- B Certification of Fire Retardant Treatment shall include:
  - 1 name of fire retarding materials used,
  - 2 compliance with local building code requirements and with AWWA Specification. C1 and C20 for lumber and C27 for plywood,
  - 3 fire retarding materials will not bleed through painted surfaces.
  
- C Shop Drawings shall include: large scale details, dimensioned plans, elevations, and adjacent work of other trades; details of anchorages, fixing methods, grain direction, joints, shims, trim, etc.; extent of detailing and scales required shall be approved by the Engineer prior to commencing the shop drawings.
  
- D Samples of each type of finished carpentry items shall be provided

##### 1.04 Quality Assurance

- A Lumber shall be new, sound, kiln-dried and seasoned, well manufactured and free from bows, twists, crooks and waves that cannot be corrected during bridging or milling. All stock shall be dressed all four sides allowing true surface for attachment of finished work.
  
- B The grade and trademark shall be provided on each piece of lumber (or bundled stock) and only the recognised official marks of association under whose rules it is graded shall be used.
  
- C Except for blocking in adjacent to finish mill-work, moisture content shall not exceed 19 percent for lumber, 12 percent for plywood and 5 percent for blocking adjacent to finish mill-work.

- D The American Lumber Standard (PS-20-70) of the US. Department of Commerce shall govern finished lumber sizes. Cross-sectional sizes of lumber expressed herein are nominal unless accompanied by a fraction or noted otherwise. Other dimensions expressed herein are to be regarded as actual.

### **1.05 Qualifications**

The work of this Section shall be executed by an approved specialist Sub-Contractor having a minimum of five years experience on projects of similar size and quality to that specified and shown.

### **1.06 Delivery, Storage and Handling**

Where sequences of operations permit, no interior lumber material shall be delivered until work containing excessive water has been completed at least ten calendar days. Materials shall be stacked to ensure ventilation and drainage. Lumber shall be protected from the elements and against dampness during and after delivery. It shall be stored under cover in a well-ventilated area of the building. Finished carpentry work shall be stored in a dry, well ventilated and air-conditioned space, matching the conditions of the finished installation.

### **1.07 Protection**

Finished carpentry work shall be protected during transit, delivery, storage and handling to prevent damage and shall be kept covered with protective wrapping.

### **1.08 Environmental Conditions**

Do not install finish carpentry work in any space until wet work in such space is dry to the satisfaction of the installer.

## **Part 2 Products**

### **2.01 Rough Carpentry - Materials**

#### **A General:**

- 1 lumber grading shall comply with " Simplified Practice Recommendations PS-20, American Softwood Lumber Standards " by U.S. Department of Commerce, and with the applicable lumbermen association rules,
- 2 plywood grading shall comply with ANSI A199.1,
- 3 Each piece of lumber shall be factory marked with the official grade mark of the appropriate association or authorised inspection service,
- 4 dimensions on the Drawings designate the nominal undressed size of the item and lumber shall be provided which is dressed S4S and worked to such patterns as shown or specified,
- 5 Lumber shall be provided which has been seasoned by drying to a moisture content not to exceed 19 percent.

B Lumber for general use shall be 200f grade of any species. For grounds lumber shall be no. 2 grade Douglas Fir, nailers and Southern Pine blocking, cants.

C Plywood shall be Backer-Structural I, Douglas Fir boards, etc. with C-D Veneers.

D Anchors and Fasteners:



- 1 bolts, nuts, studs. FS FF-B-571 and FF-B-575,
  - 2 expansion shields. FS FF-S-325; group, type, class and style best suited for the purpose,
  - 3 lag screws and bolts. FS FF-B-561, type and grade best suited for the purpose.
  - 4 nails. FS-FF-N-105, type and size best suited for the purpose Hot dipped galvanized for exterior,
  - 5 toggle Bolts. FS FF-B-588, type and class best suited for the purpose,
  - 6 wood screws. FS FF-S-111; style best suited for the purpose and hot dipped galvanized for exterior,
  - 7 power-driven fasteners may be used if permitted by the Engineer.
- E Steel Plates and Shapes. ASTM A36, galvanized for exterior use.
- F Shop primer for metals shall be zinc chromate primer with a synthetic resin carrier.
- G Preservative Treated Wood.
- 1 wood to be treated shall be wood embedded in, or in contact with, either concrete, masonry or plaster; wood plates, cants, curbs, cleats and nailing strips in connection with waterproofing, roofing and flashing,
  - 2 preservative material shall be: water-borne complying with AWPB LP-2 for use above ground and AWPB LP-22 for ground contact use or oil-borne complying with AWPB-LP-4 for use above ground and AWPB-LP-44 for ground contact use,
  - 3 pressure treat in a closed retort by vacuum-pressure process in compliance with AWPA C-2 and AWPA C-9 for plywood,
  - 4 do not use creosote preservative.
- H Fire Retarding Treated Wood:
- 1 fire-retarding chemicals shall be provided as required to suit the relative humidity and to achieve a flame spread rating not higher than 25. They shall comply with AL Test 723 and shall not contain halogens or sulphates,
  - 2 wood shall be treated to meet Building Code requirements and AWPA Specification C1 and C20 for lumber and C27 for plywood as a minimum. Fire retarding materials shall be guaranteed not to bleed through painted finish,
  - 3 wood shall be sized before treatment so that minimum cutting will be required after treatment.

## 2.02 Finish Carpentry - Materials

- A General:
- 1 in addition to requirements shown as specified, materials shall comply with applicable provisions for grading and workmanship of AWI "Quality Standards",
  - 2 provide lumber surfaced 4 sides (S4S) and worked to profiles shown,
  - 3 kiln-dry lumber to moisture content recommended by the AWI Section 100-G-3.
- B Lumber shall comply with AWI Section 100 with the following requirements:
- 1 hardwood for opaque finish: any hardwood which, when finished, will not show any grain, imperfection of other surfaces defects when used with the opaque finish specified,
  - 2 hardwood for concealed framing and blocking: economy grade, any species,
  - 3 hardwood for natural finish: premium grade or select Burma Teak (*Tectona Gradis*) as shown.
- C Plywood shall comply with AWI Section 200 veneer core, or lumber core unless otherwise specified and with the following requirements:

- 1 premium grade hardwood, Section 200-3, face veneers as shown or specified,
  - 2 premium grade softwood, Section 200-2, face veneers as shown or specified,
  - 3 plywood edges shall be banded with hardwood in accordance with Premium Grade, Section 1440-8,
  - 4 provide special banding where shown.
- D Face veneers for opaque finish shall comprise any hardwood veneer that, when finished, will not show any grain, imperfection or other surface defects when used with the opaque finish. Face veneers for natural finish shall be of teak.
- E For natural finish provide natural finish (clear finish) for items designated to receive clear finish and for opaque finish provide painted finish for items designated to receive painted finish as specified in Section 09900. For unexposed wood finish use alkyd type primer-sealer.
- F Fasteners
- 1 wood screws shall be FF-S-111, type, size, material and finish as required for the condition of use,
  - 2 nails shall be FS FF-N-105, type, size, material and finish as required for the condition of use,
  - 3 anchors shall be of type, size, material and finish suitable for the condition of use.
- G Sealants for joint sealing as specified in Section 07920.

### **2.03 Fabrication - General**

- A Lumber framing and fastening devices shall be provided as required for a rigid installation. All fabrications shall be made from field measurements with provision for scribing as required to meet built-in conditions and shall be coordinated with the work of other trades.
- B Details indicate the required type and quality of construction and modifications to conform to manufacturer's standards will be considered providing they comply with the Contract Documents. Profiles shall be maintained as shown and are subject to acceptance by the Engineer.
- C The work shall comply with AWI Section 1500, Premium Grade for sanding, filling countersunk fasteners, back priming and similar preparations for the finishing of architectural woodwork.

## **Part 3 Execution**

### **3.01 Conditions of Surfaces**

The Contractor shall examine substrata, adjoining construction, and conditions under which the Work is to be installed and the work shall not proceed until unsatisfactory conditions have been corrected.

### **3.02 Installation**

- A The Contractor shall:
- 1 whenever rough carpentry is fitted to other work obtain measurement of such other work,

- 2 coordinate installation with the work of other trades to ensure exact fit and perfect alignment,
  - 3 verify dimensions before proceeding and obtain measurements at job site for work required to be accurately fitted to other construction,
  - 4 install work plumb, level, true and straight with no distortions,
  - 5 provide shims as required,
  - 6 cutting, trimming, fitting and matching of pre-finished work will not be permitted,
  - 7 where cutting is required, scribe to fit adjoining work so as not to damage finished surfaces,
  - 8 securely fasten finish carpentry work items to blocking with concealed fasteners only. Where surface nailing is required, countersink and fill flush with the woodwork so that the finished heads are undetectable.
- B Rough framing shall:
- 1 fit closely, and be set accurately to required lines and levels,
  - 2 be secured rigidly in place in accordance with details and good practice,
  - 3 use shims of slate or galvanized steel for leveling wood members on concrete or masonry.
  - 4 be cut and fit to accommodate other work as required and in a neat workmanlike manner,
  - 5 be nailed in accordance with Housing and Home Finance Agency, publication “Technique of House Nailing”.
- C Grounds shall be provided for securing wood trim and other items in plaster work and be installed rigidly, true to line and dimension. The size shall be 38 mm by thickness required to finish flush with surface of plaster or as shown or required.
- D Cant strips shall be continuous, cut with square ends, in as long lengths as possible and be secured by nailing to previously installed blocking or nailers.
- E For repair of treated wood surfaces two heavy brush coats of the same wood preservative material shall be applied to surfaces exposed by sawing, cutting or drilling complying with AWWPA-M-4. Any surfaces, which are cut after treatment, shall have an application of heavy brush coat of same fire retarding chemicals.
- F Rough hardware and ferrous metal shall be primed with the specified paint. Fire retarding treated wood shall be painted with one coat of alkyd type paint or a moisture transmission resistant coating immediately.

### 3.03 Protection

Protect finished carpentry work so that it will be without damage at the time of completion of the Works. Damaged or soiled surfaces, panels, etc. shall be removed and replaced to the satisfaction of the Engineer.

**End of Section 06100**

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## Section 06400

### Architectural Woodwork

#### 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 Architectural Woodwork.

##### 1.02 Requirements of Regulatory Agencies

The Contractor shall treat those items required by applicable codes and those items shown, or specified, as "Fire Retardant Treated Wood".

##### 1.03 Submittals

- A Shop drawings shall include large scale details, dimensioned plans, reflected ceiling plans and elevations, adjacent work of other trades, details of anchorages, fixing methods, grain direction, joints, shims, trim etc. and shall be submitted as specified in Section 013000.
- B Samples of each of the following items shall be provided:
  - 1 plastic laminate, 300 mm square, including outside corner of various colours for selection by the Engineer,
  - 2 opaque finish (lacquer) wood veneer laminated to plywood, 300 mm square for each colour, gloss and finish specified (for alternative finish if opted for use),
  - 3 metal trim, 200 mm long, type and finish as specified,
  - 4 timber used for clear finish: 300 x 300 mm size,
  - 5 hardware exposed in the finished work (stainless steel),
  - 6 samples of any other materials specified and as required by the Engineer.
- C Certification of fire retardant treatment shall include:
  - 1 name of fire retardant materials used,
  - 2 compliance with local building codes and with AWWA Specification C1 and C20 for lumber and C27 for plywood,
  - 3 fire retardant materials will not bleed through painted or natural finish surfaces.

##### 1.04 Qualifications

The work of this Section shall be executed by an approved specialist Sub-contractor having a minimum of five years experience on projects of similar size and quality to that specified and shown. The Engineer shall have the right to inspect the fabricator's workshop prior to approval of the proposed Sub-contractor.

##### 1.05 Mock-ups

Following approval of samples, a full size visual mock-up of the decorative screens and ceilings, simulating final conditions, shall be constructed and located where directed. Full size mock-ups of balustrade handrail and wall handrail including brass/chromium plated trims and methods of fixation shall be constructed. The mock-ups, when approved, may be used in the

final work.

### 1.06 Environmental Conditions

Architectural woodwork shall not be installed in any space until wet work in such space is dry to the satisfaction of the installer and building mechanical system can maintain the relative humidity and temperature so that the woodwork will not be damaged by excessive changes.

### 1.07 Protection

Architectural woodwork shall be protected during transit, delivery, storage and handling to prevent damage and shall be kept covered with protective wrapping. Architectural woodwork shall be stored in a dry, well-ventilated and air-conditioned space, matching the conditions of the finished installation.

## Part 2 Products

### 2.01 Wood

#### A General

- 1 in addition to requirements shown and specified, material shall comply with applicable provisions for grading and workmanship of AWI "Quality Standards",
- 2 provide lumber surfaced four sides (S4S) and worked to profiles shown,
- 3 kiln-dry lumber to moisture content recommended by the AWI Section 100-G-3.

#### B Lumber shall comply with AWI Section 100 and with the following requirements:

- 1 hardwood for opaque finish: any hardwood which, when finished, will not show any grain, imperfection or other surface defects when used with the opaque finish specified,
- 2 hardwood for concealed framing and blocking: economy grade, and species,
- 3 Hardwood for natural finish: premium grade, select Burma teak (*Tectona Grandis*) and oak as shown.

#### C Plywood shall comply with AWI Section 200; veneer core, or lumber core unless otherwise specified and with the following requirements:

- 1 premium grade hardwood, Section 200-3, face veneers as shown or specified,
- 2 premium grade softwood, Section 200-2, face veneers as shown or specified,
- 3 plywood edges shall be banded with hardwood in accordance with premium grade, Section 400-8. Where natural finish is specified provide oak edges,
- 4 provide special banding where shown.

#### D Hardwood shall be teak, selected by the Engineer, for lacquered finish.

#### E Face Veneers for opaque finish shall comprise any hardwood veneer that, when finished, will not show any grain, imperfection or other surface defects when used with the opaque finish specified. Face Veneers for natural finish shall be teak veneers.

#### F For natural finish provide natural finish (clear finish) for items designated to receive clear finish, as specified in Section 09900. For opaque finish for alternative works (lacquer) polish finished substrates to eliminate marks and sander scratches and wipe clean prior to application of coats as follows. The total dry film thickness shall be between 75-125 microns:

- 1 first coat shall be alkyd resin, nitrocellulose lacquer base, 65 percent solids, opaque undercoat with colour best suited to achieve final colour appearance of subsequent

- coats, with a cold cycle of 16,
  - 2 second coat shall be opaque lacquer, nitrocellulose plasticizer base, 45 percent solids with colour and specular gloss selected by the Engineer with a cold check of 20,
  - 3 third coat shall be clear catalyzed lacquer, alkyd urea base modified nitrocellulose resin, 26 percent solids and specular gloss as selected by Engineer with a cold check of 15,
  - 4 unexposed wood finish shall be alkyd type primer-sealer.
- G Fire Retardant Treated Wood
- 1 fire retardant materials shall meet the requirements of AWPA P10,
  - 2 wood shall be treated to meet requirements of AWPCA C1 and C20 for lumber and C27 for plywood as a minimum. Fire retardant materials shall be guaranteed not to bleed through painted finish or natural finish,
  - 3 after fire retardant treatment, kiln dry to the moisture content specified herein,
  - 4 wood shall be fabricated before treatment, wherever possible, and disassembled for treatment, so that cutting and jointing will not be required after treatment. A heavy brush coat of the same fire retardant chemicals shall be applied to any surfaces which are cut after treatment.

## 2.02 Plastic Laminate

Face sheets shall be to NEMA Publication LD3, Grade GP50, Type 1; 1.6 mm thick; satin finish unless otherwise shown; and colour as selected. Backing sheets shall be non-decorative; high pressure plastic laminate; NEMA LD3, Grade BK20; and 0.8 mm thick. Edges shall be finished with plastic laminate to match face and which shall be fixed before face sheets are applied, unless otherwise shown or specified.

## 2.03 Metal

- A Structural steel shapes and plates shall be to ASTM A36 and shall be galvanised where shown or required in accordance with ASTM A386 or other approved standards.
- B Stainless steel shall conform to A1S1 Type 317.
- C Brass shall be polished brass sheet, alloy 230 complying with ASTM B36.

## 2.04 Miscellaneous Products

- A Fasteners
- 1 wood screws shall be FF-S-111, type, size, material and finish as required for the condition of use,
  - 2 nails shall be FS FF-N-105, type, size, material and finish as required for the condition of use,
  - 3 anchors shall be of type, size, material and finish as required for the condition of use.
- B For laminating plastic laminate surfaces, adhesives shall be melamine; phenol-resin, or resorcinal-resin complying with FS MMM-A-81 of a type, grade and class best suited for the purpose. For all other uses, adhesives shall be moisture resistant; comply with FS MMM-A125 type II, or MMA-A-188, type I, II or III, type best suited for the purpose.
- C Joint Fillers shall have back up rods for sealants as specified in Section 07910.
- D Sealants for joint sealing as specified in Section 07920.

## 2.05 Fabrication - General

- A Provide lumber framing for architectural woodwork, complete with all bracing and fastening devices as required for a rigid installation and as required to sustain the imposed loads. All fabrication shall be done from field measurement with provision for scribing as required to meet built-in conditions.
- B The work of this Section shall be coordinated with the work of other trades.
- C Units shall be fabricated in the largest practicable sections, assembled in the shop for trial fit and disassembled for shipment and reassembled with concealed fasteners.
- D The relative humidity and temperature shall be maintained during fabrication, storage and finishing operations, matching that of the areas of installation.
- E Details shall indicate the required type and quality of construction. Modifications to conform to manufacturer's standards will be considered providing they comply with the Contract Documents, and, at no additional cost to the Employer. The profiles shown shall be maintained and be subject to acceptance by the Engineer.
- F Reinforcing shown is a minimum and additional reinforcing shall be provided as required to ensure a rigid assembly. Exposed surfaces shall be free from dents, tool marks, warpage, buckle, glue and open joints, or other defects affecting serviceability or appearance. All joints, corners and mitres shall accurately fit. All fasteners shall be concealed and threaded connections shall be made up tight so that threads are entirely concealed.
- G Welding and brazing shall be of adequate strength and durability with joints tight and flush, smooth and clean. All exposed surfaces shall be ground and finished flush, free of weld marks. Welds or brazes on finished surfaces shall be indistinguishable from parent metal.
- H Factory finish all items where possible and defer finish touch-up, cleaning and polishing until after delivery and installation. Provide finishes as shown or specified.
- J Work shall comply with AWI Section 1500 with premium grade for sanding, filling countersunk fasteners and back priming and similar preparations for the finishing of architectural woodwork.

## 2.06 Fabrication - Specific Items

- A Skirtings shall be fabricated in as long pieces as practicable with minimum joints and joints shall be neatly and accurately made in the running length and with mitre corners.
- B Decorative screens shall be fabricated to the details and patterns shown on the Drawings.
- C Decorative ceilings shall be fabricated to the details and patterns shown on the Drawings.
- D Wall handrails and balustrade handrails shall be fabricated to the details shown on the Drawing.



## **Part 3 Execution**

### **3.01 Installation**

- A The Contractor shall:
- 1 coordinate installation with the work of other trades to ensure exact fit and perfect alignment, especially for items to be set in the vanity tops,
  - 2 verify dimensions before proceeding and obtain measurements at job site for work required to be accurately fitted to other construction,
  - 3 install work plumb, level, true and straight with no distortions providing shims as required,
  - 4 cutting, trimming, fitting and matching of pre-finished work will not be permitted,
  - 5 where cutting is required, scribe to fit adjoining work so as not to damage finished surfaces,
  - 6 securely fasten architectural woodwork items to blocking with concealed fasteners only. Where surface nailing is required, countersink and fill flush with the woodwork so that the finished heads are undetectable.
- B Decorative screens and ceilings shall be installed as shown, with adequate concealed supports from building structure. Install units inline, co-ordinating with other components and with all related trades. Install miscellaneous trim as shown.
- C Balustrade handrails shall be installed to steel supports cast into concrete as detailed. Wall handrails shall be installed to steel brackets bolted to walls as detailed. Units shall be installed in line, co-ordinating with other components and all related trades.
- D Finishings shall be applied to items as indicated and as specified in Section 09900.

### **3.02 Protection**

Protect architectural woodwork so that it will be without damage at the time of completion of the Works. Damaged or soiled surfaces shall be removed and replaced to the satisfaction of the Engineer.

**End of Section 06400**

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## Section 06610

### Fibreglass Reinforced Plastic Fabrications

#### 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 fibre reinforced plastic fabrications.

##### 1.02 Submittals

- A Product data shall include manufacturer's catalogue data showing dimensions, spacings, and construction details; design tables showing limits for span length and deflection under various uniform and concentrated loads; materials of construction.
- B Shop drawings shall detail fabrication and erection of each FRP fabrication including plans, elevations, sections, and details of FRP fabrications and their connections, anchorages and accessory items.
- C Samples of each type of FRP product proposed shall be submitted for approval.

##### 1.03 Quality Assurance

- A Material covered by these specifications shall be furnished by a reputable and qualified manufacturer of proven ability who has regularly engaged in the manufacture and installation of FRP systems and shall be approved by the Engineer.
- B Fabricator shall be a firm experienced in successfully producing FRP fabrications similar to that indicated for this project, with sufficient production capacity to produce required units without causing delay in the work.
- C Substitution of any component or modification of system shall be made only when approved by the Engineer and at no additional cost to the Employer.
- D In addition to requirements of these specifications, the Contractor shall comply with manufacturer's instructions and recommendations for work.

##### 1.04 Delivery Storage And Handling

- A All systems, sub-systems and structures shall be shop fabricated and assembled into the largest practical size suitable for transporting.
- B All materials and equipment necessary for the fabrication and installation of the grating, stair treads, handrails, ladders, weir plates, linings and structural shapes shall be stored in a manner to prevent cracking, twisting, bending, breaking, chipping or damage of any kind to the materials or equipment, including damage due to over exposure to the sun.
- C Any material which, in the opinion of the Engineer, has become damaged as to be unfit for use, shall be promptly removed from the site of work and the Contractor shall receive no compensation for the damaged material, or its removal.

- D All materials, items and fabrications for installation and field assembly shall be identified and match-marked

## **Part 2 - Products**

### **2.01 General**

- A The Contractor shall design, engineer, fabricate, and install the FRP fabrications to withstand the specified structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Each load shall be applied to produce the maximum stress in each respective component of each FRP fabrication.
- B Materials used in the manufacture of the FRP products shall be new stock of the best quality, free from all defects and imperfections that might affect the performance of the finished product.
- C All materials shall be of the kind and quality specified, and where the quality is not specified, it shall be the best of the respective kinds and suitable for the purpose intended.
- D All FRP products shall be manufactured by a pultruded process using a vinyl ester resin with flame retardant and ultra-violet (UV) inhibitor additives. A synthetic surface veil shall be the outermost layer covering the exterior surface and FRP shapes shall achieve a flame spread of 25 or less in accordance with ASTM test method E84.
- E All FRP items shall be corrosion resistant to a 5 percent concentration of either sulfur dioxide or hydrogen sulfide.
- F After fabrication, all cut ends, holes and abrasions of FRP shapes shall be sealed with a compatible resin coating to prevent intrusion of moisture.
- G FRP products exposed to weather shall contain an ultraviolet inhibitor and shall additionally receive 25 microns thick U.V. coating to shield from ultra-violet light.
- H All exposed surfaces shall be smooth and true to form.
- I Colour shall be OSHA safety yellow or gray as instructed by the Engineer.

### **2.02 FRP Gratings and Stair Treads**

- A Material
  - 1 the material shall have a glass reinforcement content of 40 to 65 percent,
  - 2 the glass fibre "E" type continuous strand glass mat shall comply with BS 3749,
  - 3 fabrication shall be from bearing bars and cross rods manufactured by the pultrusion process. Bearing bars shall be minimum 25 - 40 mm deep, 15 mm wide top and bottom flanges and 4 mm web thickness.
- B Design factor of safety shall be two. The maximum deflection in any direction shall not be more than span/180 and at the center of simple spans shall not exceed 6 mm. The fabrication shall be capable of withstanding a uniform load of 4.5 kN/m<sup>2</sup>.
- C The top surface of all panels shall have nonskid grit affixed to the surface by a baked epoxy resin followed by a top coat of baked epoxy resin.

- D Hold down clamps shall be stainless steel inset hold down with a minimum of four each per panel.

### 2.03 FRP Handrails

#### A Material

- 1 the material shall have a glass reinforcement content of 50 percent,
- 2 the glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings shall comply with BS 3749,
- 3 rails and posts shall be 50 x 50 x 4 mm thick fibre glass pultruded square tube,
- 4 kickplates shall be 100 x 12.5 (corrugated) x 3 mm thick pultruded fibre glass shape.

#### B Pultruded parts shall meet the following minimum mechanical properties:

Properties	Test Method	Values
Tensile Stress	ASTM D638	207 MPa
Tensile Modulus	ASTM D638	17 GPa
Compressive Stress	ASTM D695	207 MPa
Compressive Modulus	ASTM D695	17 GPa
Flexural Stress	ASTM D790	207 MPa
Flexural Modulus	ASTM D790	11 GPa
Shear Stress	ASTM D2344	31 MPa
Density	ASTM D792	1.66 to 1.94 g/cm <sup>3</sup>
24 hr. Water Absorption 0.6%		ASTM D570 max
Coef. of Thermal Expansion 10 <sup>-6</sup> /°C		ASTM D696 8 x
Flexural Stress	Full Section	248 MPa
Flexural Modulus	Full Section	25 GPa

- C Design shall conform to loading requirements of OSMA 1910.23, with a minimum factor of safety of 2. Fabrications shall be capable of withstanding a concentrated load of 90 kg applied at any point non-concurrently, vertically downward or horizontally. Horizontal hand rails shall be 1000 mm high with an intermediate rail at 500 mm high.

### 2.04 FRP Ladders

#### A Material

- 1 the material shall have a glass reinforcement content of 50 percent.
- 2 the glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings shall comply with BS 3749.
- 3 side rails shall be 50 mm x minimum 4 mm thick square tube.
- 4 rungs shall be 24 mm dia solid rod; at spacing of maximum 250 mm with minimum 400 mm between stringers and minimum 200 mm from adjacent walls. The top surface shall be provided with a non-slip grit surface and the rungs shall be capable of withstanding a point load of 5000 N applied at the center.
- 5 safety cages shall be provided where indicated or where the distance between landing exceeds 3500 mm. Cage hoops shall conform to the following:
  - a top or bottom hoop : 75 mm x 6 mm thick straps
  - b intermediate hoop : 50 mm x 6 mm thick straps
  - c cage traps : 50 mm x 4.5 mm thick straps spaced 225 mm on center around the hoop
  - d each hoop shall be able to withstand both a tangential point load of 740 N and a vertical point load of 1200 N applied at any point on the hoop. The maximum allowable deflection at the point of application of the load shall not exceed 25

- mm and there shall be no permanent deflection of the hoops after removal of the load.
- 6 end caps shall be molded.
  - 7 fixing brackets shall be at maximum 2000 mm centers and be mechanically bonded into the concrete by means of suitable lugs or stainless steel anchor bolts bonding lug. The fixing shall be capable of withstanding shear and pull-out load of 5000 N.
  - 8 when supported horizontally over a span of one metre, with the climbing face uppermost, and with a load of 1000 N applied at the center of the span, the ladder shall not deflect more than 15 mm at the point of application of the load, and shall show no permanent deflection after removal of the load.

**B Pultruded parts shall meet the following minimum mechanical properties.**

<b>Properties</b>	<b>Test Method</b>	<b>Values</b>
Tensile Stress:	ASTM D638	
Longitudinal direction		207 MPa
Transverse direction		48 MPa
Compressive Stress:	ASTM D695	
Longitudinal direction		207 MPa
Transverse direction		103 MPa
Flexural Stress:	ASTM D790	
Longitudinal direction		207 MPa
Transverse direction		69 MPa
Shear Stress:	ASTM D2344	
Longitudinal direction		31 MPa
Transverse direction		31 MPa
Tensile Modulus:	ASTM D638	
Longitudinal direction		17 GPa
Transverse direction		17 GPa
Compressive Modulus:	ASTM D695	
Longitudinal direction		17 GPa
Transverse direction		17 GPa
Flexural Modulus:	ASTM D790	
Longitudinal direction		11 GPa
Transverse direction		6 GPa
Shear Modulus:		
Longitudinal direction		3 GPa
Transverse direction		3 GPa
Density	ASTM D792	1.66 - 1.94 g/cm <sup>3</sup>
Water absorption (24 hr immersion)	ASTM D570	max 0.60%
Barcol hardness	ASTM D2583	45
Coefficient of thermal expansion	ASTM D696	8 x 10 <sup>-6</sup> /°C
Thermal conductivity	ASTM C177	0.5 W/mk

## 2.05 FRP Covers

**A Material**

- 1 composition of glass reinforced plastic with a glass reinforcement content of 50 percent,
- 2 glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings to BS 3749,
- 3 thickness shall be 5 mm minimum at any point,
- 4 structural decking units produced in 500 mm wide by 100 mm deep shallow trough sections,

- 5 vertical flanges shall incorporate a horizontal recess into which a seal and shear block is fitted,
- 6 to prevent ingress of water and dirt, an extruded plastic capping shall be fitted.

B The design loads shall be:

- 1 imposed loads : 1.5 kN/m<sup>2</sup>,
- 2 personnel loads : 1.8 kN/m<sup>2</sup>,
- 3 wind suction : 1.0 kN/m<sup>2</sup>,
- 4 maximum deflection : L/150.

C Molded closure panels shall be provided at ends to suit installation configuration.

D Peripheral fasteners shall be grade 316 stainless steel.

## 2.06 FRP Weir Plate

A Material

- 1 composition of glass reinforced plastic with a glass reinforcement content of 50 percent,
- 2 glass fibre 'E' type continuous strand glass mat or continuous glass strand rovings to BS 3749,
- 3 minimum thickness shall be 6 mm.

## 2.07 FRP Lining

A Unless otherwise specified the interior concrete faces of all structures in contact with sewage or sewage gases shall be lined with a prefabricated FRP liner.

B The liner shall consist of a minimum thickness of 7 mm FRP laminate. The laminate liner base layer shall be composed of a 4 mm thickness layer with minimum 29 percent "E" glass reinforcement to a maximum 71 percent resin content. The outer layer (in contact with liquid) shall be composed of a resin rich 2 mm thick layer of approved vinyl ester with at least two layers of "C" glass veil meeting 90 percent resin to 10 percent "C" glass ratio by weight.

C FRP liner shall be shaped to match the required dimensions and configurations, as shown on the drawings, and installed in sections, as required, for proper concrete placement and FRP field jointing techniques.

D Each FRP liner shall be equipped with pre-molded pipe openings, such that proper bonding can be obtained between the FRP liner and the pipe as otherwise specified, and as shown on the drawings.

E All field bonded FRP joints shall meet the minimum requirements of the liner and be installed such that the bond is water tight and no loss of strength occurs through the joint.

F Field applied joint strips shall be minimum 100 mm wide, 6 mm thick and composed of laminate consisting of 71 percent vinyl ester resin content to 29 percent "E" glass reinforcement.

G Prefabricated FRP liners shall have bonding lugs (concrete anchors) consisting of 100 mm long FRP strips or FRP round studs, bonded to the concrete adjacent face to each FRP panel, not to exceed 500 x 500 mm approximate spacing. The shape of each bonding lug shall be to produce a secure bond in the cast-in-situ concrete such that the FRP liner is

held firmly in place, in contact with the concrete surface, alleviating any tendency of the liner to become unbonded and “float” away from the concrete.

## **Part 3 - Execution**

### **3.01 Preparation**

The Contractor shall coordinate and furnish anchorages, setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, including concrete inserts, sleeves, anchor bolts, and miscellaneous items having integral anchors that are to be embedded in concrete or masonry construction. Sleeves shall be set in concrete with top flush with finish surface elevations and protected from water and concrete entry.

### **3.02 General Installation**

- A For fastening to in-place construction anchorage devices and fasteners shall be provided where necessary for securing miscellaneous FRP fabrications to in-place constructions. These shall include threaded fasteners for concrete and masonry insets, toggle bolts, through-bolts, lag bolts and other connectors as required.
- B Cutting, drilling and fitting shall be performed as required for installation of miscellaneous FRP fabrications. The FRP fabrications shall be set accurately in location, alignment, and elevation with edges and surfaces level, plumb, true, and free of rack and measured from established lines and levels.
- C Temporary bracing or anchors shall be provided in formwork for items that are to be built into concrete masonry or similar construction.
- D Items specified shall be as indicated and in accordance with manufacturer’s instructions.

### **3.03 Workmanship**

All field cut and drilled edges, holes and abrasions shall be sealed with a catalyzed resin compatible with the original resin as recommended by the manufacturer. Sealing of the edges shall prevent premature fraying at the filed cut edges.

### **3.04 Installations of FRP Liners**

- A Joint strips shall be applied to the concrete side of the FRP liner on the internal faces of manholes or other sewage retaining structures.
- B Immediately before taking over by the Employer, and after inspection for leakage, an additional joint strip shall be fixed on the internal face of the FRP liner.
- C FRP liner shall be adequately braced and carefully handled such that excessive defections, breaking, or cracking of the liner does not occur during handling, installing and pouring concrete.
- D A non-slip finish shall be paced on horizontal benching surfaces, platforms and step points by dusting the surface of the laminate with silica sand as soon as the resin has set to a soft gel. Surplus sand shall then be brushed no less than 24 hours later.

**End of Section 06610**



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## 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.
- 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 10°C and 24°C, 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:

<b>Property</b>	<b>Test Method</b>	<b>Typical Results</b>
Tensile strength at break - film	ASTM D638	Long 42 N/mm <sup>2</sup> Trans 51 N/mm <sup>2</sup>
Tensile strength at break - membrane	ASTM D638	Long 4.2 N/mm <sup>2</sup> Trans 5.1 N/mm <sup>2</sup>
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 <sup>2</sup> /24 hours
at 35°C, 90 % RH		1.0 g/m <sup>2</sup> /24 hours
Adhesive softening point	ASTM D36	110 °C

- E 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.
- F 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.
- G 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.
- H 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.
- I 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.

## 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 10°C or more than 35°C. 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.

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.

- G 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.

### **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.
- E 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.
- F 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 07200

### Building Insulation

#### Part 1 General

##### 1.01 Description

Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with Building Insulation.

##### 1.02 Submittals

- A Manufacturer's specifications and installation instructions shall be provided for the type of insulation.
- B 600 x 600 mm square samples of the type of insulation shall be provided.

##### 1.03 Delivery, Storage and Handling

- A Insulation materials shall be delivered in the manufacturer's unopened containers or packages, fully identified with trade name, type, class and other identifying information. Delivery shall be sequenced to avoid project delays and to permit proper co-ordination of the work.
- B Materials shall be stored above grade and protected from weather and damage from any source. The building insulation shall not become wet or soiled and the Contractor shall comply with other precautions and recommendations of the manufacturer to protect insulation from deterioration.

#### Part 2 Products

##### 2.01 Insulation

- A Rigid plastic insulation, which shall be 50mm thick on walls and 70 mm on roofs, shall be extruded rigid closed-cell polystyrene foam board with ship-lapped edges having the following properties:

Property	Typical Results	Test Method
Density	35 kg/m <sup>3</sup>	
Five-year aged average thermal conductivity when tested at 24°C	0.032 W/m.K	ASTM C 518 or DIN 52612
Compressive strength (av)	280 kPa	ASTMD1621 or DIN 53421
Water Absorption (av)	1%	ASTM D2842
Water vapour permeability (av)	0.79 perm.cm	ASTM C355

- B Where required for fire rated construction rigid polyester impregnated fibreglass insulation with non-combustible fabric covering shall be provided. It shall comply with FS HH-1-521E, Type 1, and be of the thickness, density and type tested and approved for the required ratings.



- C Expanded polystyrene insulation which is not manufactured with, or contains chlorofluorocarbons (CFC's) which are known have harmful effects on the earth's ozone layer and the environment, shall be used.
- D Adhesives that are compatible with the insulation, protection course and substrata materials shall be used.
- E For securing fire rated insulation to the ceiling, galvanised steel clamps of suitable size and strength shall be provided to suit the installation.

## **Part 3 Execution**

### **3.01 Acceptance of Surface**

All substrata, supports, and conditions under which this work is to be performed shall be examined and work shall not proceed until unsatisfactory conditions are corrected. Any defects in the work resulting from substrata, supports, and conditions shall be corrected by the Contractor without additional cost to the Employer.

### **3.02 Installation**

- A The manufacturers' instructions shall be complied with for the particular condition of use and type of insulation in each case. If printed instructions are not applicable to the condition of use, the manufacturer shall be consulted for specific recommendations before proceeding with installation.
- B Insulation shall extend for the full thickness over the entire area to be covered, unless otherwise shown. Insulation shall be cut and joined tightly around all obstructions so that no voids exist in the insulation course.
- C Mechanical attachments shall be used of the type and spacing as specified and as recommended by the insulation manufacturer for the thickness and condition of use shown. For adhesive applied insulation clips, adhesive and spacing of clips shall be that recommended by the manufacturer for the condition and substrata indicated.

### **3.03 Protection**

Temporary protection shall be provided to insulation to prevent damage or deterioration from weather or physical abuse. Assemblies to permanently protect insulation shall be completed as soon as possible.

### **3.04 Extent Of Works**

All buildings shall be insulated to meet the specified requirements for energy conservation. The basement area slab/beam soffits shall be insulated with rigid fiber glass in all areas exposed to the weather at ground floor level and all roofs/walls shall be insulated with the required thicknesses of extruded polystyrene unless larger thickness is shown on the Drawings.

**End of Section 07200**

## Section 07250

### Cementitious Fireproofing

#### Part 1 General

##### 1.01 Description

Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with cementitious fire proofing.

##### 1.02 Performance Requirements

The cementitious fireproofing system shall provide a fire rated assembly rating of two hours to all exposed structural steel including cross-bracing and miscellaneous steel members.

##### 1.03 Submittals

- A The following product data shall be provided:
- 1 product characteristics, performance and limitation criteria,
  - 2 manufacturer's installation instruction in accordance with Section 1300,
  - 3 manufacturer's certificate in accordance with Section 01400,
  - 4 proof that the products meet or exceed the specified requirements,
  - 5 test reports in accordance with Section 01400,
  - 6 certified test reports indicating the following:
    - a minimum bond strength of fireproofing shall be twenty times weight of fireproofing materials, tested in accordance with ASTM E760,
    - b fire test reports of fireproofing application to substrate materials similar to project conditions,
    - c reports from reputable independent testing agencies, of product proposed for use, which indicate conformance to ASTM E119 and ASTM E84.
- B A 10 m<sup>2</sup> sample shall be provided applied to representative substrates on site.

##### 1.04 Quality Assurance

- A Documentary evidence shall be provided indicating that the specified materials to be used, have been successfully utilized on work of similar scope to that shown, and specified, for this project for a minimum period of three years.
- B Application shall be executed by an approved specialist sub-contractor having a minimum of three years successful experience in applying the specified material.
- C The Contractor shall submit certification of acceptability of fireproofing materials to the authority having jurisdiction.

##### 1.05 Environmental Requirements

- A Spray fireproofing shall not be applied when temperature of substrate material and surrounding air is below 5°C.
- B Ventilation shall be provided in areas to receive fireproofing during and 24 hours after application to dry material to maintain non-toxic, non-polluted working areas. Temporary

enclosures shall be provided to prevent spray from contaminating air.

## **Part 2 Products**

### **2.01 Materials**

Cementitious spray fireproofing shall be factory mixed, asbestos free, cementitious material blended for uniform texture and of non-fibrous materials conforming to the following requirements:

- 1 bond strength: ANSI / ASTM E736, 9.6 kN/m<sup>2</sup> when set and dry,
- 2 bond impact: ASTM E760, no cracking, flaking, or delamination,
- 3 dry density: ASTM E605, minimum average density of 240 kg/m<sup>3</sup> with minimum individual density of 224 kg/m<sup>3</sup>,
- 4 compressive strength: minimum 24 kN/m<sup>2</sup>,
- 5 water: clean, potable,

## **Part 3 Execution**

### **3.01 Examination**

Prior to commencement of work the Contractor shall verify the following:

- 1 surfaces are ready to receive work,
- 2 clips, hangers, supports, sleeves, and other items required to penetrate fireproofing are in place,
- 3 ducts, piping, equipment, or other items, which would interfere with application of fireproofing, are not positioned until fireproofing work is complete,
- 4 voids and cracks in substrate are filled and projections are removed where fireproofing is exposed to view as a finish material.

### **3.02 Preparation**

Substrate shall be cleaned of dirt, dust, grease, oil, loose material, or other matter, which may affect bond of fireproofing. Incompatible materials, which affect bond, shall be removed by scraping, brushing, scrubbing, or sandblasting and the surface shall meet the requirements of the manufacturer.

### **3.03 Protection**

Adjacent surfaces and equipment shall be protected from damage by overspray, fall-out, and dusting, and ductwork, in areas where fireproofing is being applied, shall be sealed off.

### **3.04 Application**

Fireproofing, overcoat and sealer shall be applied in accordance with the manufacturer's instructions. Fireproofing shall be applied in sufficient thickness to achieve rating, with as many passes necessary to cover with monolithic blanket of uniform density and texture.

### **3.05 Field Quality Control**

- A Installation shall be examined within one hour of application to determine variance due to shrinkage, temperature and humidity. Where shrinkage and cracking are evident, the mixture and method of application shall be adjusted as necessary.
- B The installed fireproofing shall be re-inspected for integrity of fire protection, prior to

concealment of work. Unacceptable work shall be corrected and further inspected to verify compliance with requirements, at no extra cost to the Employer.

### **3.06 Cleaning**

Clean all work and remove excess material, over-spray, droppings, and debris. Fireproofing shall be removed from materials and surfaces not specifically required to be fireproofed.

**End of Section 07250**

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## Section 07270

### Firestops

#### Part 1 General

##### 1.01 Description

Furnish all plant, labour, equipment, appliances and materials and performing all operations in connection with fire stopping.

##### 1.02 Performance Requirements

- A Fireproofing Materials: ASTM E119 and ASTM E814 to achieve specified fire rating.
- B Surface Burning: ASTM E84 with a flame spread / fuel contributed / smoke developed rating of 1/11/111.

##### 1.03 Submittals

The following product data shall be provided:

- 1 data on product characteristics, performance and limitation criteria,
- 2 manufacturer's installation instructions,
- 3 manufacturer's certificate stating that products exceed the specified requirements.

##### 1.04 Quality Assurance

- A The manufacturer shall provide documentary evidence indicating that the proposed materials have been successfully utilized on work of similar scope to that shown and specified for this project for a minimum period of three years. The work shall be executed by an approved specialist Sub-contractor having a minimum of three years successful experience in applying the specified material.
- B Materials shall conform to applicable code for fire resistance ratings and surface burning characteristics. The Contractor shall submit certification of acceptability from authority having jurisdiction indicating approval of combustibility.

##### 1.05 Mock-Up

The Contractor shall provide a mock-up of applied firestopping material to a representative substrate surface. If accepted, the mock-up will demonstrate minimum standard for the Work. The mock-up may remain as part of the Work.

##### 1.06 Environmental Requirements

Materials shall not be applied when temperatures of substrate material and ambient air are below 15°C. This minimum temperature shall be maintained before, during, and for three days after installation of materials.

##### 1.07 Sequencing

Sequence work to permit firestopping materials to be installed after adjacent and surrounding work is complete.

## **Part 2 Products**

### **2.01 Materials**

- A Fire resistance rating shall be equal to the hourly rating of the floor, wall, or partition into which the firestop will be installed. Firestopping materials shall be asbestos-free and capable of maintaining an effective barrier against flame and gases in compliance with the U.L. Building Materials Directory and conforming to the following:
  - 1 durability and longevity: permanent,
  - 2 side effects during installation: none,
  - 3 long term side effects: none.
- B Primers shall be of a type recommended by firestopping manufacturer for specific substrate surfaces.
- C Finished color shall be dark gray.

### **2.02 Accessories**

- A Dam material: as per manufacturer's instructions.
- B Retainers: clips to support mineral fiber matting.

## **Part 3 Execution**

### **3.01 Preparation**

- A The Contractor shall verify that openings are ready to receive the Work.
- B Substrate surfaces shall be cleaned of dirt, dust, grease, oil, loose material, or other matter which may affect bond of firestopping material and incompatible materials, which affect bond, shall be removed.

### **3.02 Application**

Materials shall be applied in accordance with manufacturer's instructions and in sufficient thickness to achieve rating and uniform density and texture. Materials shall be installed at walls or partition openings which contain penetrating sleeves, piping, ductwork, conduit and other items requiring firestopping. After firestopping material has cured dam material shall be removed.

### **3.03 Cleaning**

Adjacent surfaces shall be protected from damage by material installation and cleaned of fire stopping materials.

**End of Section 07270**

## Section 07500

### Membrane Roofing

#### Part 1 General

##### 1.01 Description

The principal work of this Section shall be furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with membrane roofing system including, but may not be limited to, the following waterproofing membrane, insulation, sand bed, Sika tiles, cement sand mortar, geotextile fabric or natural stone

##### 1.02 Submittals

- A The following product data shall be provided:
- 1 manufacturers' specifications and installation instructions for roofing membrane and accessory items and for each item of proprietary material used, showing compliance with these Specifications,
  - 2 copies of mix designs with support material for all mortars,
  - 3 copies of manufacturer's certificate of mill tests of all cement, reinforcing steel and embedments,
  - 4 shop drawings showing details, dimensions, locations and installation methods of roofing system including membrane, insulation, precast pavers, flashings and all accessories. The drawings shall indicate the following:
    - a profiles, slopes, low and high points, dimensions, joints,
    - b arrangement of units,
    - c detail of special design or shapes, anchors, inserts, joints etc.,
    - d connections to adjoining work or materials,
    - e reinforcing for each unit,
    - f method of installation and anchoring,
    - g positions of service outlets including roof drains, vent pipes, exhaust fans, roof hatches, skylights, etc.,
  - 5 complete engineering data for fabrication, reinforcement and anchorage.
- B Each precast unit when delivered shall be numbered clearly on an unexposed surface to correspond with identity numbers on erection drawings.
- C Detailed outline of sequence and methods of erection shall be provided.
- D Samples of membranes, insulation, sika tiles, aggregates and other items required by the Engineer.
- E A written affidavit stating that the roofing applicator is licensed or approved by the roofing manufacturer.
- F Guarantee stating that the roofing membrane 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.



### **1.03 Mock-Up**

The Contractor shall provide a 3m x 3m mock-up of roofing system with full sized architectural precast sika tiles units. The mock-up shall be representative of the finished work in all respects indicating joint conditions and all other features as will be used in the final work. The mock-up assembly will be used as a standard for judging acceptability of work on project and may be used in the finished work.

### **1.04 Quality Assurance**

- A Roofing and flashing shall be executed by a specialist roofing Sub-Contractor licensed, franchised or approved by the roofing materials manufacturer, using experienced skilled roofers, having a minimum of five years experience in the installation of materials specified herein on projects comparable to this Project.
- B All roofing and flashing work shall be applied in strict accordance with the roofing manufacturer's written requirements and specifications applicable to roof conditions. Where additional work or materials, or greater quantities of materials than required by roofing manufacturer are specified herein, these Specifications shall govern.
- C The roofing material manufacturer's representative shall inspect the work during roof installation, at no additional cost, and furnish a copy of his inspection reports to the Engineer. The reports shall be on the roofing manufacturer's standard inspection report form, dated and signed.
- D Roofing work shall not proceed during inclement weather and the manufacturer's recommendations shall be followed for application and curing under specific climatic conditions.

### **1.05 Pre-Installation Co-Ordination**

After approval of all materials, and prior to installation, a pre-roofing conference shall be held at the job site between Engineer, Contractor, roofing sub-contractor and manufacturer's representative. The parties shall review Drawings, specifications and approved materials and correct conflicts, if any, between approvals and specification requirements. They shall examine job site conditions, including inspection of deck, material labels and methods of storing materials and confirm that all curbs and edges are provided and correctly installed. They shall also review installation procedures, scheduling and temperature requirements, and establish protection methods for finished roof from other trades.

### **1.06 Final Inspection**

Upon completion of the installation, an inspection shall be made by a representative of the roofing material manufacturer in order to ascertain that the membrane roofing system has been properly installed. If there is any deviation from this specification, without the prior written consent of the roofing material manufacturer, the manufacturer shall have the option of refusing the guarantee.

### **1.07 Delivery, Storage and Handling**

- A Roofing materials shall be delivered in manufacturer's unopened containers or bundles, fully identified with brand, type, grade, class and all other qualifying information. Bulk materials shall be delivered with certification from the manufacturer stating the name, type and grade of each product used. Units shall be delivered from plant to project site in

accordance with schedule and proper setting sequence. "Rejected" shall be marked conspicuously on materials which have once been wet or damaged and remove from job site.

- B Materials shall be stored in a dry location, in such manner as to prevent damage or intrusion of foreign matter. Precast units shall be stored free of the ground and protected from mud or rain splashes. Units shall be covered with firmly secured covers and protected from dust, dirt or other staining materials.
- C Precast units shall be transported, stored and handled in a manner to avoid undue strains, hair cracks, staining, or other damage.
- D A certificate shall be provided accompanying each load (or furnish manufacturer's blanket certificate) for each bulk product used in the work.

### **1.08 Protection**

- A Waterproofing system installation shall be protected from damage during construction so that it will be without any indication of abuse or damage at the time of completion. The structure shall be protected from damage resulting from spillage, dripping and dropping of materials and any other work damaged during roofing membrane operations shall be repaired.
- 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 will rest with the Engineer.

### **2.02 Ancillary Buildings**

- A Water Proofing Membrane
  - 1 provide the products and systems specified in the material manufacturer's latest published manual for the and type of substrate shown,
  - 2 bitumen sheet membrane shall be flame bonded single-ply membrane, 4 (+/-0.2) mm thick composed of asphalt or bitumen modified with thermoplastic resins and reinforced with non-woven polyester fabric,
  - 3 cant strips shall be cement and sand mortar, in the proportion of 1:3 by volume.
- B Roof insulation shall be light-weight concrete with an average density of 500 to 700 kg/m<sup>3</sup> and average thickness shall be 100 mm.
- C Standard sika tiles shall be 800 X 800 X 40 mm and water proofed with an appropriate additive and shall be manufactured by a specialist roofer having at least ten years experience. Tiles shall be of a strength capable of taking live roof load of 2.5 kN/m<sup>2</sup> and shall have a special section formed at their edges so that when laid against each other two adjacent edges shall form a special joint section that will hold the sealant.

- D Sika skirting and corner elements shall be laid as indicated on the drawings along the periphery and on the corners of the roof. They shall rest on the concrete against the upstands or parapet to ensure a continuous coved skirting providing the same profile as that of the slabs. Elements shall have rounded corners be waterproofed as for the sika tiles and shall have sealant at all edges.
- E Sand shall be as specified in Section 03300.
- F Joint sealant shall be as specified in Section 07920.

### 2.03 Storage Reservoirs

- A Water proofing membrane shall be as specified in Section 07100.
- B Geotextile fabric shall be needled polypropylene thermally bonded fabric with the following properties:
  - a thickness 1.4 mm
  - b weight 300 g/m<sup>2</sup>
  - c tensile strength
    - longitudinal direction 13 kN/m
    - transverse direction 17 kN/m
- C Sand bed shall be as specified in Section 03300.
- D Natural stone shall be single sized, uncrushed aggregate of max size 20 mm and properties shall be as specified in Section 03300.

## Part 3 Execution

### 3.01 Preparation

- A Surfaces to receive membrane roofing shall be free of projections, voids, depressions, scale efflorescence, loose material, laitence, oil grease and other foreign contaminants. Before starting work, the Contractor shall inspect all surfaces to receive membrane and report in writing to the Engineer, any surfaces that are not suitable for correct application of the membrane. If any surfaces are unsuitable to receive membrane, the Contractor shall see that same are corrected by the respective trade prior to application of his work.
- B All preparation of surfaces, including construction joints shall be completed before membrane waterproofing is installed.

### 3.02 Installation of Membrane Roofing.

- A At the start of the installation, and periodically as work progresses, the Contractor shall provide the services of the manufacturer's technical representative at the job site as often as deemed necessary by the manufacturer to advise on all phases of this work. The roofing system shall be installed in strict accordance with manufacturer's direction for conditions of each application.
- B All surfaces to receive roofing membrane shall be primed using products and methods recommended by the roofing membrane materials manufacturers. Cant strips shall be applied at all edges and around any penetrations in the roofing, as shown on Drawings.

- C Roofing membrane shall be applied in accordance with the manufacturer's instructions and recommendations and joints shall be overlapped a minimum of 100 mm. All roof outlets, pipes, sleeves, and other projections through roof deck shall be flashed to provide tight construction throughout.

### **3.03 Flood Testing**

- A The horizontal areas of waterproofing shall be tested prior to the installation of insulation. Testing shall be by flooding sections of the waterproofed area, dammed as required, with a minimum 50 mm head of water for 48 hours. Any leaks shall be marked and repaired when the membrane is dry. Any area where leaks occur shall be drained, thoroughly dried, repaired, and then re-tested. At completion of flood testing, remove all dams and traces of water to the satisfaction of the Engineer.
- B Installation of sand beds, insulation, stone filling, sika tiling, all of which are applied over the waterproofing, shall not start until such time as the membrane is leak free and has been accepted by the Engineer.

### **3.04 Insulation Installation**

Light weight foam concrete shall be laid average 100 mm thick to the required falls and cross falls with one percent slope.

### **3.05 Installation of Precast Sika Tiles System**

Sika tiles shall be set on 20 mm thick sand bed with uniform joints as indicated on Drawings. The tiles shall be laid on concrete ribs and direction of flutes shall be in the same direction to permit the flow of rainwater.

### **3.06 Protection and Cleaning**

- A All damage to the building resulting from this work or operations shall be made good. Particular care shall be taken to avoid staining any part of the exposed structural or finished work. Hoisting of materials shall be done with extreme care. All exposed surfaces shall be protected by approved means.
- B At completion of work under this Section, the Contractor shall remove from the site and legally dispose of packaging, containers and other accumulated materials, and leave the work in a clean and satisfactory condition.

**End of Section 07500**

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## Section 07600

### Sheet Metal Flashing

#### 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 sheet metal flashings and expansion joint covers.

##### 1.02 Qualifications

The work shall be performed by a firm having five years experience in the installation of materials specified herein on projects comparable to this Project.

##### 1.03 Submittals

- A Samples of each metal shall be provided and the Engineer's review and acceptance of samples will be for colour and finish only.
- B Shop drawings shall be provided showing metal flashings and accessories with complete information concerning fabrication, installation, joint details, and fastenings.
- C Manufacturer's specifications and installation instructions and other data shall be provided to show compliance with the Contract Documents.
- D A ten year guarantee shall be provided against leaks resulting from defects of materials or workmanship. Upon notification of such defects, within the guarantee period, make the necessary repairs and replacements at the convenience of the Employer at no additional cost to the Employer.

##### 1.04 Delivery, Storage and Handling

Materials shall be delivered in tagged bundles or in manufacturer's unopened containers fully identified to show name, brand, type, grade and thickness and shall be stored in a protected and dry environment.

#### Part 2 Products

##### 2.01 Materials

- A Aluminium flashings and expansion joint covers shall be fabricated from 20 gauge NS3 or NS4 aluminium alloy to comply with BS1450.
- B Aluminium shall be finished with 2 coats of fluoropolymer resin to a minimum thickness of 30 microns.

##### 2.02 Fabrication

Units shall be custom fabricated. Measurements and dimensions shall be verified at the job site and work shall be coordinated and scheduled with the work of related trades.

## **Part 3 Execution**

### **3.01 Conditions Of Surfaces**

- A Examine substrate, adjoining construction and conditions under which work is to be installed.
- B Do not proceed with work until unsatisfactory conditions have been corrected.

### **3.02 Installation**

- A Flashings and expansion joint covers shall be provided with all accessories to provide a watertight installation.
- B Units shall be set level and plumb, true to line, be coordinated with other work and anchored securely in place with aluminium alloy screws and/or concealed non-ferrous clips.
- C Concealed contact surfaces of dissimilar metals and metals contacting concrete shall be coated with bituminous paint as specified in Section 8520.
- D In general, flashings and expansion joint pieces shall be furnished in appropriate lengths with joints welded as necessary. Angles and the like on flashings and expansion joint covers requiring dressing shall be mechanically welded where required for watertightness.
- E Sheet metal shall be designed and detailed for a temperature of 21°C at time of installation with allowance made for a 32°C ambient temperature. All necessary adjustments shall be made for installations at other than design temperature.

### **3.03 Cleaning**

Upon completion of work, flux residues shall be removed with a solution of washing soda or ammonia, then drenched with clear water.

**End of Section 07600**

## Section 07724

### Access Hatches

#### Part 1 General

##### 1.01 Description

The principal work of this Section shall be furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with access hatches complete, as indicated.

##### 1.02 Quality Assurance

Unless otherwise specified all work specified herein shall be fabricated as specified in Section 05500.

##### 1.03 Submittals

- A Manufacturers installation instructions shall be provided.
- B Shop drawings and product data indicating unit dimensions, method of anchorage, and details of construction shall be provided.

#### Part 2 Products

##### 2.01 Materials

Materials of construction for steel access hatches shall be as indicated. Materials shall be new, sound and shall conform to the following:

- 1 Stainless steel type 316L access hatch.
  - a dimensions: as indicated on schedule.
  - b leaf type: double or single as indicated on schedule.
  - c safe working load: 7.5 kN/m<sup>2</sup>.
  - d frame: 6 mm minimum thickness mill finished 316L stainless steel.
  - e door: 6mm min. thickness mill finished diamond plate 316L stainless steel.
  - f all hardware: type 316L stainless steel.
  - g grip handle: vinyl.
  - h fabricate frame with anchor flange around perimeter and 40 mm diameter drainage coupling.
  - I reinforce door with 316L stainless steel stiffness.
  - j bolt hinges to underside of door. Pivot on torsion bars.
  - k fabricate doors to open 90 degrees with assistance of spring operators and automatically lock into open position.
  - l furnish with snap lock and removable grip handle.
- 2 Aluminum Access Hatch
  - a dimensions: As indicated on schedule
  - b leaf Type: Double or single as indicated on schedule.
  - c safe working load: 7.5 kN/m<sup>2</sup>.
  - d frame: 6mm minimum thickness mill finished aluminum channel.
  - e door: 6 mm minimum thickness mill finished diamond aluminum plate.
  - f all hardware: Type 304 stainless steel.
  - g grip handle: Vinyl.



- h fabricate frame with anchor flange around perimeter and 40 mm diameter drainage coupling.
- I reinforce door with aluminum stiffeners.
- j bolt hinges on underside of door. Pivot on torsion bar.
- k fabricate doors to open 90 degrees with assistance of spring operators and automatically lock into open position.
- l furnish with snap lock and removable grip handle.

## **Part 3 Execution**

### **3.01 Condition Of Surfaces**

The Contractor shall examine all conditions related to the work of this section and ensure they are satisfactory to perform a complete installation in operating order. Any unsatisfactory conditions shall be reported to the Engineer.

### **3.02 Installation**

All products in this section shall be installed in accordance with manufacturer's instructions. All aluminium in contact with concrete shall be bituminous coated.

### **3.03 Clean-Up**

All protective masking shall be removed and surfaces cleaned, leaving them free of all imperfections. All cartons, wrapping, etc., resulting from the work of this section shall be removed from site and disposed of in a legal manner.

**End of Section 07724**

## Section 07810

### Metal Framed Skylights

#### 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 prefabricated metal framed skylights (pyramid Type).

##### 1.02 Standard Specifications

- A Except as otherwise shown or specified skylight items shall be fabricated from extruded aluminium ASTM B221 or B308, finished with 3 coat of fluoropolymer resin to match the building aluminium. The profile of skylight members are indicated to establish the design intent only; it is the Contractor's responsibility to correctly sizing the skylight members and submit all design calculations to the Engineer for approval.
- B Where units are not available as a standard manufactured product, units shall be custom fabricated complying with the requirements shown and specified.
- C Each item shall be fabricated in the shop as a complete unit for coordination with adjoining work. Anchoring and flashing flanges, offsets, cant strips and nailers for roofing, expansion sleeves (concealed on exposed fascias), hardware and non-corrosive bearings for operating parts, and gaskets and sealant recesses shall be provided as required to make the installation weathertight.
- D Except as otherwise shown, or specified, after completion of shop fabrication each unit of work shall be cleaned and treated.

##### 1.03 Qualifications

The work shall be executed by an approved specialist sub-contractor having five years experience in the installation of materials specified herein on projects comparable to this project.

##### 1.04 Submittals

- A Copies of manufacturer's specification, standard drawings and installation instructions and other data as may be required shall be submitted to show compliance with these specifications.
- B Samples of each exposed metal finish required for skylight units including 300 mm long sections of profiles with all attached accessories such as gaskets, beads, hardware etc., and polycarbonate sample fixed in the profile shall be provided. Samples of metal of the same alloy and gauge to be used for the work shall be submitted. Samples will be reviewed by the Engineer for colour, texture and specular gloss only.
- C Shop drawings and structural calculations for the design, fabrication and installation of prefabricated skylight unit shall be provided including details at not less than 1:5 scale. The drawings shall show jointing, anchorage, accessory items, shop finishes,

polycarbonate thicknesses, fixing details, waterproofing terminations, and any other details as directed by the Engineer.

- D The complete installed skylight shall be guaranteed by the Contractor for a period of five years from the date of Substantial Completion of the Works, against leakage, defective material and workmanship.

### 1.05 Testing

The contractor shall carry out appropriate tests on the completed skylight installation to ensure that whole assembly is watertight and air-tight and shall provide test certificates from approved testing agency as directed by the Engineer.

### 1.06 Cleaning And Protection

The skylight shall be protected during construction operations and left absolutely clean (inside and outside) on completion of the works.

## Part 2 Products

### 2.01 Skylight

#### A General

1. Barrel dome shaped skylights with double polycarbonate lights shall be provided in configurations as shown on Drawings. Sloped glazing must have a safety factor of 1.5.
2. The frame shall be as per approved sample with the Engineer.
3. The assembly must withstand 120 kg/m<sup>2</sup> horizontal pressure, 100 kg/m<sup>2</sup> negative pressure and 120 kg/m<sup>2</sup> downward pressure in any possible combination.
4. The assembly shall have 'U' value of 3.18 w/m<sup>2</sup>k and shading coefficient of 0.81.
5. Skylight assembly shall be watertight and shall have continuous trench drainage system for collection of rainwater and also shall have an interior gutter to collect and discharge condensate.
6. The framework shall be rigid extruded aluminium sections designed to meet the performance requirements.

#### B Aluminium Finish

1. Remove die markings prior to finishing operations and 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. This work shall be performed in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.
2. For aluminium with three coats of fluoropolymer resin all coatings shall have a minimum thickness of 40 microns and shall be tested, where required by the Engineer, using an Ultrasoniscope Eddy Current - thickness meter. The preparation of aluminium shall conform to BS 1615 and the finish shall match the building in colour, as per approved sample with the Engineer. All riveted and screened components are to be coated before assembly.

- C The skylight system shall incorporate an integral extruded aluminium gutter system. Gutter intersections shall be mechanically fastened and shall incorporate a neoprene gasket under compression to provide a positive seal. The gutters shall include an adjustable gutter support. The extruded aluminium adapter shall be positively sealed to the extruded aluminium gutter through the use of a neoprene gasket under compression.

- D Hardware shall be fabricated of stainless steel complying with ASTM A167 or white bronze or aluminium and finished to match the components to which it is fixed. All hardware shall be approved by the Engineer.
- E The Contractor may reinforce aluminium profiles with steel sections to support the loads, as long as the steel sections are galvanized, separated from aluminium sections and fully covered by matching aluminium profiles.

### **Part 3 Execution**

#### **3.01 Condition Of Surfaces**

The Contractor shall examine the substrates and adjoining construction, and conditions under which the work will be installed. Work shall not proceed until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

#### **3.02 Installation Coordination**

The complete installation of skylight units shall be fully coordinated and compatible with the roofing system.

#### **3.03 Installation- Skylights**

Skylight units shall be installed as shown, and in accordance with the manufacturer's instructions. Each unit shall be sat level and plumb, true to line and coordinated with other work. They shall be anchored securely in place, by welding, bolting, or screwing to the substrate where required for proper support. Where required for waterproof roof construction set flanges of units in roofing mastic, and leave surfaces smooth and clean for application of roofing and all other items to be embedded into or in contact with the roofing.

**End of Section 07810**

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## Section 07910

### Joint Fillers and Gaskets

#### 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 joint fillers and gaskets.

##### 1.02 Submittals

- A The following manufacturer's data shall be provided:
  - 1. Published data, or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications, is recommended for the application shown, and is compatible with each other material in the joint system.
  - 2. Complete instructions for handling, storage, installation and protection of each product.
- B A sample of each type of exposed joint filler or gasket shall be provided. Samples will be reviewed by the Engineer for colour and texture only.
- C Notwithstanding the types of joint fillers and gaskets specified herein, the Contractor shall in all cases be responsible for providing sealant materials the best of their respective kind, compatible with adjoining materials and suitable for the purpose intended, all at no additional cost to the Employer.

##### 1.03 Delivery, Storage and Handling

- A Materials shall be delivered in manufacturers' unopened containers or bundles fully identified with brand, type, grade, class and all other qualifying information.
- B Materials shall be stored in a dry location in such a manner as to prevent damage or intrusion of foreign matter. Materials which have once been wet or damaged shall be conspicuously marked "Rejected" and removed from the job site.

#### Part 2 Products

##### 2.01 General

- A The 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, may be acceptable subject to the Engineer's approval.
- B Joint fillers and gaskets shall be provided as shown or, if not shown, the manufacturer shall be consulted to determine the proper size and shape considering joint movement and conditions at time of installation. They shall be as recommended by the manufacturer for proper performance in each specific condition of use.
- C The Contractor shall provide only the type of joint filler which is compatible with the

joint surfaces and each sealant or caulking compound, as stated in the data published by the manufacturers of the joint filler and the sealant or caulking compound, or as certified by the joint filler manufacturer for each application.

- D Pressure-sensitive adhesive shall be applied to joint fillers and gaskets, wherever applicable and at Contractor's option, to facilitate installation.
- E For exposed gaskets or joint fillers, the colour shall be provided as shown or, if the colour is not shown, it will be selected by the Engineer from the manufacturer's standard colours. For concealed joints, provide the manufacturer's standard colour which has the best overall performance characteristics shall be provided.

## **2.02 Expansion Joints**

- A Expansion joints shall be non-extruding, resilient bituminous type to ASTM D1751, bituminous type to ASTM D994.
- B Closed cell, cross linked, non absorbent, polyethylene joint filler shall be to ASTM D3575 and not less than 34.5 kPa for 25 percent compression deflection; resistant to petroleum oils and solvents and with surface water absorption of not more than 5 percent.

## **2.03 Concealed, Expanded Neoprene Gasket - General Purpose**

Closed Cell: ASTM D 1056, Grade SEC-41.

## **2.04 Moulded, Resilient Neoprene Gasket**

ASTM D 2000, 50 to 70 shore A durometer, non- cellular, moulded or otherwise fabricated to form the sizes and shapes shown or as required to effectively seal each joint.

## **2.05 Gasket Lubricant**

Non staining lubricant which bonds and seals gasket in place when cured, as recommended by the gasket manufacturer.

# **Part 3 Execution**

## **3.01 Condition Of Surfaces**

The Contractor shall examine the joint surfaces and the conditions under which the work is to be done. The work shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

## **3.02 Installation**

- A The installation of each type of joint filler or gasket shall comply with the manufacturer's instructions and shall be applied in continuous runs without voids or interruptions, except as may be otherwise shown. The joint filler or gasket shall be trimmed for tight fit around obstructions or elements penetrating the joint. The surface or self-skin on moulded or extruded types of cellular joint fillers shall not be punctured.
- B The face edge of joint fillers shall be depressed accurately, wherever used as backup for sealant, as shown or as specified by sealant manufacturer for proper application of sealant.

- C Exposed edges of joint fillers and gaskets shall be recessed slightly behind the face of adjoining surfaces unless shown otherwise.

### **3.03 Protection**

Joint fillers and gaskets shall be protected during the remainder of the construction period so that they will be without indication of deterioration or damage at the time of completion of the Works.

**End of Section 07910**



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## Section 07920

### Sealants

#### 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 joint sealants and accessories in building trade work.

##### 1.02 Submittals

- A. The following information shall be provided:
1. Published data or manufacturer's letter, clearly indicating that each product to be furnished complies with these Specifications, is recommended for the application shown and is compatible with each other material in the joint system.
  2. Complete instructions for handling, storage, mixing, priming, installation, curing and protection of each type of sealant.
- B. Samples of each type of exposed sealant shall be provided, samples shall be 300 mm long installed between two samples of the materials to be sealed, fully cured. Samples will be reviewed by the Engineer for colour and texture only.
- C. Notwithstanding the types of sealant specified herein, the Contractor shall in all cases be responsible for providing sealant materials the best of their respective kinds, compatible with adjoining materials and suitable for the purpose intended, all at no additional expense to the Employer.

##### 1.03 Environmental Conditions

The installation of sealants shall not proceed during inclement weather unless all requirements and manufacturer's instructions can be complied with, and unless the work can proceed in accordance with the agreements of the pre-installation meeting. The installation of sealants shall not proceed under extreme temperature conditions which would cause joint openings to be at either maximum or minimum width, nor when such extreme temperatures or heavy wind loads are forecast during the period required for initial or nominal cure of elastomeric sealants. Sealants shall not be installed when the ambient temperature is above 30° C. Whenever possible, schedule the installation and cure of elastomeric sealants during period of relatively low temperatures (but well within manufacturer's recommended range) so that subsequent tensile stresses upon the cured sealants will be minimised.

##### 1.04 Pre-Installation Meeting

Prior to the installation of sealants a meeting shall be held at the project site to review the material selections, installation procedures and co-ordination with other trades. In attendance shall be representatives of the Contractor, manufacturer, the Engineer and other trades or sub-contractors affected by the sealant installation. The parties shall examine sample applications to determine and record whether all parties agree that the proposed installations are likely to perform as required.

### 1.05 Sample Application

- A. The Contactor shall provide sample applications of sealants at locations designated by the Engineer. Samples shall represent the primary types of materials, substrate surfaces, joint size, exposure, and other conditions to be encountered in the work. Preparation, priming, application, and curing, shall comply with manufacturer's recommendations and actual proposed methods. The applications shall be scheduled, with allowance for sufficient curing time, so that samples may be examined and any necessary adjustments made at least one week prior to date scheduled for commencing installation of the work.
- B. Samples shall be visually examined for staining, dirt pickup, shrinkage, colour, general workmanship and appearance. Sealant shall be cut and pulled from each sample joint to examine for internal bubbles or voids, adhesion, and general compatibility with substrate.

### 1.06 Delivery, Storage and Handling

- A. Materials shall be delivered in manufacturers' unopened containers, fully identified with brand, type, grade, class and all other qualifying information.
- B. Materials shall be stored in a dry location, in such a manner as to prevent damage or intrusion of foreign matter. Materials which have once been wet or damaged shall be conspicuously marked "Rejected" and removed from the job site.

## Part 2 Products

### 2.01 Materials - General

- A. If more than one of the manufacturer's products comply with the requirements for any item specified herein, provide the specific product recommended by the manufacturer for the particular condition of use in each case.
- B. The 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, may be acceptable subject to the Engineer's approval.
- C. Only sealants, and joint primers which are compatible with the joint surfaces and backing or filler materials, as stated in the manufacturer's published data, or as certified by the manufacturer for each application shall be provided. The Contractor shall confirm the compatibility of sealants that may be in contact with each other.
- D. The Contractor shall determine the proper hardness or consistency of elastomeric sealants in consultation with the manufacturer, considering joint movement and exposure for the size of joint shown.
- E. In general, provide sealants with the following ranges of hardness (fully cured sealant at 24° C):
  - 1. For joints subject to maximum movement and nominal exposure to weather and abrasion: 15 to 25 Shore A durometer hardness.
  - 2. For joints subject to moderate movements and severe weather exposure or moderate abrasion: 25 to 40 Shore A durometer hardness.
  - 3. For joints subject to minimum movement and severe abrasion: 35 to 60 Shore A durometer hardness.
- F. In general, for elastomeric sealants, provide sealants having the lowest modulus of

elasticity which is consistent with the degree of exposure to wear and abrasion. Any sealant exposed to traffic must have strength and modulus sufficiently high to resist damage by traffic.

- G. For fully concealed joints, the manufacturer's standard colour of sealant which has the best overall performance characteristics for the application shown shall be provided. For exposed joints provide the colour shown, or if the colour is not shown, provide a colour, in each case selected by the Engineer from manufacturer's standard colours, to match or blend with adjoining materials in a manner to be determined by the Engineer.
- H. Elastomeric sealants produced by any manufacturer who will not agree to send a qualified technical representative to the project site when requested, for the purpose of rendering advice concerning the proper installation of his materials, shall not be used and the sealant will be rejected by the Engineer.

## **2.02 Sealants**

- A. One-part silicone rubber sealant (1SRS) - exterior glazing shall be one-component elastomeric sealant, FS-TT-S-001543, class A, type II non-sag.
- B. Two-part polyurethane modified sealant (2-PUMS) - exterior-general application shall be FS TT-S-00227, class A, type II non-sag, elastomeric sealant.

## **2.03 Interior Glazing Sealants**

One-part high modulus silicone rubber sealant (1HMSRS) shall be one-component elastomeric sealant, FS-TT-S-001543, class A, type II non-sag acetoxy type of a colour to be selected by the Engineer.

## **2.04 Interior Sealants**

- A. Polyisobutylene/Polybutene Mastic Compound (PPMC) shall be heavy bodied non-drying, non-hardening, non-skinning compound specifically recommended as an acoustical sealant.
- B. Silicone Sanitary Sealant (SSS) (All wet areas unless otherwise noted) shall be FS-TT-S-001543, class B, type II non-sag, elastomeric sealant containing fungicide for mildew resistance.

## **2.05 Miscellaneous Materials**

- A. Joint cleaners, primers and sealers shall be as recommended by the manufacturer of the sealant, for each specific joint surface and condition.
- B. Pressure-sensitive polyethylene tape, or other plastic tape, as recommended by the sealant manufacturer shall be used to prevent bond of the sealant in the heel of the joint.

# **Part 3 Execution**

## **3.01 Acceptable Conditions**

The Contractor shall examine the component surfaces and fillers of the joints to be sealed, and the conditions under which the work is to be done. Work shall not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

### 3.02 Preparation

- A. Bonding joint surfaces shall be cleaned to remove deleterious substances which might interfere with bond or otherwise impair the work. Elastomeric sealants shall not be applied to joint surfaces previously painted or treated with sealer, curing compound, water repellent or other coatings, unless a laboratory durability test of bond-cohesion has been performed and successfully demonstrated that bond will be durable. The test method shall comply with procedures of the Federal Specification, or other referenced standard, as applicable to the particular sealant.
- B. Paint and other coatings or substances shall not be applied to surfaces adjoining joint surfaces until sealants have been installed and are nominally cured, so that adhesion will not be impaired by migration of such substances onto the joint surfaces.
- C. Concrete and masonry joint surfaces shall be etch bonding surfaces with a 5 percent solution of muriatic acid to remove excess alkalinity and shall be rinsed thoroughly with a diluted ammonia solution, and then with clear water, and dry before installation of elastomeric sealants.

### 3.03 Installation

- A. The manufacturer's instructions shall be complied with for the use and installation of each type of sealant, unless otherwise shown or specified.
- B. The bonding joint surfaces shall be primed and sealed in accordance with the sealant manufacturer's recommendations and avoiding migration of primer or sealer onto adjoining surfaces and remove any spillage promptly.
- C. Bond breakers shall be installed in joints as shown, and wherever recommended by the sealant manufacturer, to prevent bond of the sealant to surfaces where such bond might impair the performance of the sealant. The surface or skin of compressible rod type bond breaker shall not be punctured.
- D. The Contractor shall comply with the manufacturer's printed instructions and recommendations, except as may be otherwise shown, or except as may be otherwise directed (and recorded) by the manufacturer's representative. The manufacturer's technical representative shall be present when beginning the installation of each major type of sealant.
- E. The Contractor shall employ only tradesmen who are experienced in the use of the materials specified and shall use only the types of equipment recommended by the sealant manufacturer.
- F. Compounds shall be applied in continuous beads or rivers, filling joint from the bottom without openings, voids or air pockets. Compounds shall be forced to sides of joint so as to carefully and thoroughly "wet" opposite joint bond surfaces, forming equal areas of contact with sealant. Compounds shall be confined to joint areas shown by use of masking tapes or other precautions to prevent spilling and migration onto adjoining surfaces and shall be applied in concealed compression joints accurately so that excess compound will not exude from the joint.
- G. Elastomeric sealants shall be applied to the depth shown or, if none is shown, applied in accordance with the manufacturers recommendations and the following general

limitations:

1. in joints subject to traffic or other abrasion, to a depth equal to 75 percent of the joint width, but not less than 10 mm and not more than 19 mm.
  2. in joints not subject to traffic or other abrasion, to a depth equal to 50 percent of the joint width, but not less than 6 mm and not more than 13 mm.
- H. Exposed surfaces shall be tooled so as to compress sealants to the profile shown or, if none is shown, surfaces shall be slightly concave except for providing a slight wash on horizontal joints where horizontal and vertical surfaces meet. Against rough surfaces or in joints of uneven widths the appearance of excess sealant shall be avoided by locating the sealant well back into joint wherever possible. Excess sealant shall be removed promptly as the work progresses and the adjoining surfaces cleaned as may be necessary to eliminate any evidence of spillage.
- I. If job progress, or any other condition, shall require the installation of sealants at temperatures below those recommended by the manufacturer, the manufacturer's representative shall be consulted to establish the minimum provisions required to ensure satisfactory work. The conditions under which such installations must proceed and the provisions made to ensure satisfactory work shall be recorded in writing.

### **3.04 Curing and Protection**

The sealants shall be cured in accordance with the manufacturer's instructions, to obtain maximum bond to surfaces, cohesive strength and durability at the earliest possible date. The sealants shall be protected during the remainder of the construction period, so that they will be without any indication of deterioration or damage at the time of completion of the Works.

### **3.05 Performance Test**

After curing exterior joints exposed to the weather, the sealant system shall be tested for leaks by applying a stream of water perpendicularly from a 19 mm hose at normal city water pressure or at a pressure determined by the Engineer. Approximately 5 percent of the exposed joint system where leakage could be observed shall be tested. The tests shall be conducted in the presence of the Engineer who will determine the actual percentage of joints to be tested, and the period of water flow exposure, based on any observed leakage. Any leaks shall be repaired and re-tested as directed.

**End of Section 07920**

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## Section 08100

### Metal Doors and Frames

#### 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 hollow metal doors and frames.

##### 1.02 Requirements of Regulatory Agencies

Doors and frames shall comply with fire rating requirements as specified and applicable local codes and shall be fabricated in accordance with these requirements for the door opening specified. Fire separation shall be provided as tested in accordance with ASTM E152 or equivalent test method.

##### 1.03 Qualifications

Provide doors and frames manufactured by a firm specialising in the production of hollow metal work and, for hollow metal doors and frames for fire rated openings, manufactured by a firm whose units are inspected and tested for fire rated doors and the certificates are approved by the local authorities.

##### 1.04 Submittals

- A. Manufacturer's certification for each metal door and frame which is shown as fire rated. Doors should comply with requirements of NFPA and local authorities.
- B. Shop Drawings:  
Show typical details of all conditions at large scale (not less than 1:5) for every opening and number all doors in accordance with a plan agreed with the Engineer.
- C. Samples . 450 x 600 mm cut-away sample door with provisions for:
  1. Lockset.
  2. Pair of hinges.
  3. Corner section of door frame.

#### Part 2 Products

##### 2.01 Materials

- A. Cold-rolled sheet steel shall conform to ASTM A 366 and A 568, be free from scale, pitting or other defects, E finish and with stretcher levelled for doors.
- B. Galvanized sheet steel shall conform ASTM A 526 and be galvanized in accordance with ASTM A 525 with coating Designation G 90 (275 g/sq. m) zinc coating and phosphatized.
- C. Supports and anchoring devices shall be structural steel ASTM A 36; or sheet steel, ASTM A 366 cold-rolled; or ASTM A 569 hot-rolled and ASTM A 568; not less than 16 gauge (1.5 mm) fabrication; and comply with ASTM A 153, Class B.



- D. Filler shall be sound deadening, heat-retarding mineral fiber insulating material.
- E. Fasteners shall be galvanized or cadmium plated steel.
  - 1. Bolts and nuts shall be ASTM A 307, Grade A.
  - 2. Expansion bolts shall be FS-FF-S-325, Group III, expansion shield (self-drilling tubular expansion shell bolt anchors), Type 1 or 2 with galvanized bolts.
  - 3. Machine screws shall be FS-FF-S-92, Carbon steel, Type III cross-recessed, design I or II recess, style 2c flat head.
- F. Sheet steel primers shall be one of the following, compatible with finish and intended service (refer to Section 09900).
  - 1. FS TT-P-57 Type I (oil / alkyd, zinc chromate, iron oxide base).
  - 2. FS TT-P-57 Type II (alkyd, zinc chromate, iron oxide base).
  - 3. FS TT-P-86 Type III (alkyd, red lead base).
  - 4. FS TT-P-664 (rust-inhibiting, lacquer-resisting, zinc chromate, iron oxide base).
- G. Galvanized steel primer shall be FS TT-P-641 Type II (alkyd, zinc dust-zinc oxide).
- H. Weather/acoustic seals shall be closed cell sponge neoprene.
- I. Glazing shall be as specified in Section 08800.
- J. Provide manufacturers standard hinges, pull and locking handles, door closures and all other hardware required for the operation indicated and as shown on the Drawings. Finish of all hardware items to be approved by the Engineer. All locks shall be grouped with a Master Key System.

## 2.02 Fabrication

- A. Fabricate doors and frames to the design and dimensions shown in accordance with best shop practices. Unless otherwise shown, fabricate doors and panels to a thickness of 45 mm and take field measurements where co-ordination with adjoining work is necessary.
- B. Make hollow metal work strong, rigid, neat in appearance and free from defects. Reinforce corners of doors as required to prevent twisting or sagging.
- C. Form exposed surfaces free from warp, wave and buckle, with all corners square, unless otherwise shown. Form moulded members straight and true, with joints coped or mitered, well formed, and in true alignment. Dress welded joints on exposed surfaces smooth so they are invisible after finishing.
- D. Provide undercuts and clearances for doors as required and for rated doors and panels within the limitations established by the authority having jurisdiction. Prepare doors and frames to receive weather seals and acoustic seals shown or specified.
- E. Provide a full mitre continuously welded on back side at frame corners and stops with edges straight and true. Grind welds smooth and flush on exposed surfaces.
- F. Accurately machine, file and fit exposed connections with hairline joints unless otherwise shown.
- G. Conceal fastenings unless otherwise shown and countersink exposed screws using flat, Philips head screws.

- H. Conform to the requirements of the "Structural Welding Code" of the American Welding Society for the welding of steel and provide welds of adequate strength and durability.

### 2.03 Door Construction

- A. Doors shall be made of commercial quality, level, cold-rolled steel conforming to ASTM Designation A-366 and free of scale, pitting or other surface defects. Face sheets shall be 18 gauge for door openings size upto 2000 x 2200 mm and 14 gauge for door openings size greater than 2000 x 2200 mm. Zinc coating of not less than 0.183 kg/sqm shall be used for exterior door face sheets.
- B. Door faces, as well as lock and hinge edges, shall have a smooth, seamless and unbroken surface. Doors shall be rigid and neat in appearance, free from warpage or buckle and corner bends shall be true and straight and of minimum radius for the gauge of metal used.
- C. Lock and hinge edges shall be formed by full overlap of each face sheet around continuous angle reinforcements projection welded to each sheet at the hinge and lock edges for the full height of door assuring maximum strength.
- D. Face sheets shall be stiffened by continuous vertical formed steel stiffeners. Stiffeners shall be formed from not less than 22 gauge steel, spaced not more than 150 mm apart and securely attached to face sheets by spot welds not more than 125 mm on centers. Spaces between the stiffeners shall be insulated the full height of the door and insulation shall be minimum 9.6 kg/cu.m density. Laminated core face sheets shall be bonded under controlled heat and pressure to an inner core consisting of honeycomb, polystyrene extending full width and height of the door. The honeycomb core shall have a minimum 12 mm cell and compression strength shall be 365 kN/sq.m minimum. The pre-expanded polystyrene slab core shall have a density of 16 kg/cu.m. Gypsum core board intended for openings requiring fire rated temperature rise doors. Core shall be mineral based fiberboard having a density of 288 kg/cu.m.
- E. Edge seams formed by the face sheets at the lock and hinge stiles shall be closed by a continuous heli-arc weld extending the full height of the door and then ground, filled and cosmetically treated to provide a smooth, seamless surface.
- F. All doors shall be mortised and reinforced to allow field application of hinges and locks in accordance with the approved hardware schedule and templates supplied by the hardware contractor. Where surface-mounted hardware is to be applied, doors shall have reinforcing plates only and all drilling and tapping shall be by others. The minimum gauges for reinforcing plates shall be as follows:
1. Hinge and pivot reinforcements - 7 gauge
  2. Reinforcements for lock face, flush bolts, concealed holders, concealed or surface-mounted closers-12 gauge.
  3. Reinforcements for other surface-mounted hardware - 16 gauge.
- G. Where specified or scheduled, doors shall be provided with mouldings in accordance with glass opening sizes shown on approved shop drawings.
- H. Louvers shall be of the type of construction providing the free air space specified by the Engineer.
- I. After fabrication, all tool marks and surface imperfections shall be dressed as required to make all faces and vertical edges smooth, level and free of all irregularities. Doors shall

then be chemically treated to insure maximum paint adhesion and coated on all exposed surfaces with a rust inhibiting primer which is fully cured before shipment.

- J. Hollow metal panels shall be made of the same materials and constructed and furnished in the same way as specified for hollow metal doors.
- K. All doors shall be chemically washed, rinsed and dried prior to receiving one coat of baked-on texture prime paint.

#### **2.04 Frame Construction**

- A. Frames shall be made of commercial grade cold-rolled steel conforming to ASTM designation A-366 and be 16 gauge for door openings up to size 2000 x 2200 mm and 12 gauge for door openings greater than 2000 x 2200 mm. Zinc coating of not less than 0.183 kg/m<sup>2</sup> shall be used for exterior openings.
- B. All frames shall be custom made units with integral trim of the sizes and shapes shown on approved shop drawings.
- C. All finished work shall be strong and rigid, neat in appearance, square, true and free of defects, warp or buckle. Moulded members shall be clean cut, straight and of uniform profile throughout their lengths.
- D. Jamb depths, trim profile and backbends shall be as scheduled by the Engineer and shown on approved shop drawings.
- E. Corner joints shall have all contact edges tightly closed with trim faces mitred and welded and finished smooth. Use of gussets will not be permitted.
- F. Minimum depths of stops shall be 16 mm. Hospital or cut-off stops, where scheduled, shall be capped at 45° at heights shown on the approved shop drawings. All jamb joints below these stops shall be ground and filled smooth.
- G. When shipping limitations dictate, frames for large openings shall be fabricated in sections designed for splicing in the field by others.
- H. Frames for multiple or special openings shall have mullion and/or rail members which are closed tubular shapes having not visible seams or joints.
  - 1. All joints between faces of abutting members shall be securely welded and finished smooth.
  - 2. Frames shall be mortised, reinforced, drilled and tapped at the factory for fully templated mortised hardware only in accord with approved hardware schedule and templates provided by the hardware contractor.
  - 3. Where surface mounted hardware is to be applied, frames shall have reinforcing plates only.
- I. Minimum thickness of hardware reinforcement plates shall be:
  - 1. Hinge and pivot reinforcements-7 gauge, 38 mm x 220 mm min.
  - 2. Strike reinforcements-12 gauge
  - 3. Flush bolt reinforcements - 12 gauge
  - d. Reinforcements for other surface mounted hardware - 12 gauge.
- J. Floor anchors shall be welded inside each jamb with holes provided for floor anchorage and minimum thickness of floor anchors shall be 14 gauge.

- K. Frames for installation in masonry walls shall be provided with adjustable jamb anchors of the T-strap, stirrups and strap or wire type. The number of anchors provided shall be as follows per jamb:
  - 1. Frames up to 2.2 m height - 3 anchors
  - 2. Frames 2.2 m to 2.4 m height - 4 anchors
  - 3. Frames over 2.4 m height - 1 anchor for each 600 mm or fraction in height.
- L. Frames for installation in stud partitions shall be provided with steel anchors of suitable design not less than 18 gauge thickness, securely welded inside each jamb as follows:
  - 1. Frames up 2.2 m height - 3 anchors
  - 2. Frames 2.2 m height - 5 anchors
  - 3. Frames over 2.4 m height - 5 anchors plus one additional for each 600 m or fraction over 2.4 m.
- M. Frames to be anchored to previously placed concrete, masonry or structural steel shall be provided with anchors of suitable design as shown on approved shop drawings.
- N. Dust cover boxes or mortar guards of not less than 24 gauge steel shall be provided at all hardware mortises on frames to be set in masonry or plaster walls.
- O. All welded frames shall be provided with a steel spreader temporarily attached to the feet of both jambs to serve as a brace during shipping.

## **2.05 Labeled Doors and Frames**

All doors and frames for labeled openings shall be of the construction and design, having specific Underwriters Laboratories, Factory Mutual and Warnock Hersey International approval according to current procedures for 3-hour or 2 hour fire rating.

## **2.06 Weather/Acoustic Seals**

Shall comply with the Specifications and be formed to the profiles shown to receive weather seals and acoustic seals. Frames shall be drilled and tapped as required. Seals shall be installed in single lengths for each side with uniform exposure of 10 mm, using adhesive. Other attachments shall be as detailed and as recommended by the seal manufacturer.

## **2.07 Shop Painting**

- A. Clean, treat and paint surfaces of fabricated hollow metal work, inside and out, whether exposed or concealed in the construction. Thoroughly clean all metal surfaces of loose scale, shavings, filings, dirt and other deleterious materials by use of wire brushes or other effective means. Remove grease and oil by one of the methods specified in SSPC-SP-1-63 "Solvent Cleaning". Fill as required to seal seams in edges.
- B. Finishes
  - 1. Generally:
    - a. Remove die markings prior to finishing operations.
    - b. 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.
    - c. Perform this work in addition to the finish specified.
    - d. Scratches, abrasions, dents and similar defects are unacceptable.
  - 2. Fluoropolymer Resinous Coating:
    - a. AA-C12-RIX in colour to be selected by the Engineer

- b. Using 70 percent minimum "Kynar 500 Fluorocarbon Resin" (Pennwalt Chemicals Corp.) with dry film thickness of top coat of 0.025 mm (1.0 mil).
- c. Finish shall meet the following:
  1. Dry film thickness within minus 5 to plus 25 percent of specified thickness and testing device at processor's option.
  2. Abrasion resistance shall conform to ASTM D968 with coefficient of abrasion to average 70.
  3. Pencil Hardness shall be F-2H Minimum.
  4. Salt spray shall be to ASTM B117 to withstand 1,000 hours in 5 percent salt fog at 35°C and shall retain adhesion, corrosion resistance, colour and gloss with no more than a few blisters no larger than No. 4 (ASTM D714).
  5. Humidity Test shall be to ASTM D2247 to withstand 1,000 hours, 100 percent relative humidity at 35 °C to 37 °C and shall retain adhesion, corrosion resistance, colour and gloss.
  6. Weatherometer shall be to ASTM G23 to withstand 500 hours exposure in Sunshine Arc Weatherometer, Model XW-R, under 60/60 Dew Cycle conditions with no significant evidence of chalk, colour or gloss change.
  7. Formability shall be to ASTM D1737 with no failure in adhesion or rupture of coating when bent 180 degrees around a 3 mm mandrel.
  8. Gloss shall be to ASTM D523 with average specular gloss of 30 for glossmeter geometry of 60 degrees.
  9. Adhesion shall result in no removal of finish after 1.5 mm cross hatching to base metal, impacting to the point of metal rupture, and subjecting to application and quick removal of cellophane tape.

## 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. Set hollow metal frames at locations shown, in perfect alignment and elevation, plumb, level, straight, true and free from rack.
- B. Brace frames to prevent displacement.
- C. Extend frame anchorages below fills and finishes, except over membrane waterproofed areas and anchor bottom of frames to floors with anchor bolts or with power driven fasteners. Co-ordinate the installation of built-in anchors for wall and partition construction as required with other work.
- D. After wall construction has been completed, remove temporary braces, including spreaders at base of 3 sided frames and leave surfaces smooth and undamaged.
- E. Apply hardware in accordance with hardware manufacturer's instructions and fully co-ordinate with him in making the necessary door and frame preparations for and fixing all hardware.
  1. Drill and tap metal door and frames for machine screws as required.
  2. Do not use self-tapping sheet metal screws.
  3. Anchor panels in place with concealed fasteners.

4. Adjust door installation to provide uniform clearance at head and jambs, and to contact stops uniformly.
  5. 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 re-fix after painting of doors is completed. Adjust and lubricate hardware for proper operation at completion and throughout the Contract Maintenance Period. Instruct Employer's staff in the proper maintenance and adjustment of all hardware supplied.

### **3.03 Protection and Cleaning**

Upon completion of installation, clean exposed metal surfaces as recommended by manufacturer and leave ready for final painting. Protect units during construction period against deterioration and damage. Replace damaged components as instructed by the Engineer.

**End of Section 08100**

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## 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
  - a. Particleboard core
    1. 32 mm mill option hardwood when used with edge glued construction.
    2. 32 mm softwood shall be used for edge framed construction.
  - b. 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/m<sup>2</sup> 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/mm<sup>2</sup> for internal shutters and 980 N/mm<sup>2</sup> 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 (1½) 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**



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## Section 08365

### Rolling Service Doors

#### 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 service doors.

##### 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 Service Doors 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 door 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 1:4 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.
- D. Operating and Maintenance Manuals. Three copies of the manufacturer's operating and maintenance manuals including parts lists and all other information needed for proper operation and maintenance of Rolling Service doors.

##### 1.05 Delivery, Storage and Handling

Deliver rolling service doors 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 General

- A. All doors shall be provided by a single manufacturer
- B. Service door openings shall be equipped with approved insulated doors.
  - 1. Curtains:
    - a. Curtains shall be of interlocking flat slats, rolled not drawn, formed in many curves without sharp bends from galvanized and bonderized steel material.
    - b. Slats designed to adequately resist a minimum wind load of 980 N/mm<sup>2</sup>.
    - c. Inside curtain face shall be comprised of self-locking rigid PVC extrusion cover encasing 19 mm thick expanded polystyrene foam insulation. Use expanded polystyrene insulation which is not manufactured with, nor contains, chlorofluoro-carbons (CFC's).
    - d. Curtain to have a continuous thermal break from sill to above lintel, with no metal to metal contact on the interior side of the door.
    - e. Ends of the alternate slats be provided with wind locks which engage bars and lock the curtains into the guide.
    - f. Bottom of curtain shall be reinforced with two angles, separated by polystyrene expanded foam insulation, and fitted with neoprene bottom weatherseal.
  - 2. Counterbalance:
    - a. Curtain to be coiled on a pipe or barrel of size sufficient to carry the door load with a deflection no to exceed 1:400 of opening width.
    - b. To be evenly balanced by helical springs contained in the pipe.
    - c. All springs shall be anchored to the same tension rod and held in position by the same adjusting wheel accessible from the outside.
  - 3. Coil Brackets shall be of precision formed steel plate, with sealed ball bearing and minimum thickness 4.8 mm designed to house ends of coils.
  - 4. Hoods:
    - a. Coil to be housed with a minimum of 24 gauge steel-metal hood, galvanized and bonderized with a high grade zinc coating per ASTM standards.
    - b. Lintel weather stripping to be applied to minimize air infiltration, comprised on nylon brush stripping attached to lintel extending the full width of the opening.
  - 5. Guides:
    - a. Built structural steel roll-formed channels to form a slot of sufficient depth to retain curtains in guides against heavy wind pressure.
    - b. Guide is designed with an integral wind lock bar.
    - c. Structural Steel angles of minimum 4.8 mm thickness.
  - 6. Guide Insulation Assembly:
    - a. Jambs at each of end of the opening will be totally weather stripped and furnished with a thermal break to minimize heat loss transmission from interior to exterior.
    - b. Guide insulation assembly will be equipped with a continuous brush seal application extending from floor to lintel, both inside and outside.
  - 7. Test Procedure:
    - a. Thermal transmittance test results in accordance with ANSI/ASTM C-236 will be submitted to the engineer upon request.
    - b. Thermal transmittance due to conduction (of the total door and opening) shall not exceed the (U) value of 3.58 W/m<sup>2</sup>k.
- C. Safety Device and Weather Seal:
  - 1. Curtain bottom bars shall be provided with a weather seal and electrical safety device which shall be an electrical device working in conjunction with the operator control.
  - 2. A compressible strip shall be mounted along the bottom of each rolling door curtain.

3. Strip shall compress, activating the electrical control that will automatically stop and return the door to its fully raised position.
4. Compressible strip shall also serve as a weather strip along the bottom of the door.

D. Electric Power Operators:

1. Motor:
  - a. Doors shall be provided with an electrically operated motor and controls wired for operation on voltage indicated in electrical drawings.
  - b. Operator shall be bracket-mounted and provided with a protective galvanized sheet metal housing.
  - c. Motor shall be high-starting tongue hoist-type having sufficient power to operate the door at an average speed of 0.3 m/s.
2. Controller:
  - a. Doors shall be controlled by a momentary contact, 3-button pushbutton station marked OPEN, CLOSE, STOP, and an automatic screw-type limit switch which will break the switch at termination of travel.
  - b. Pushbutton stations shall be housed in NEMA 4X enclosures.
  - c. High-efficiency work gearing, running in an oil bath shall be furnished together with a spring-set, solenoid-operated brake completely housed to protect against damage, dust, and moisture, and a magnetic reversing contactor in NEMA Type 4X enclosure.
  - d. Emergency hand chain operator which does not affect the timing of the limit switch shall be provided to operate the door in case of power failure or removal of the motor for inspection or servicing.
3. Operators:
  - a. Operators shall be designed to transmit motion to the door without shock and shall automatically release motor from drive unit prior to stalling, so as to prevent damage to unit from overload.
  - b. An efficient heat and current-sensing overload protective device, installed integrally with the unit, shall break the control circuit to eliminate damage to motor windings.
4. Motors shall be the manufacturer's standard power, except motors shall be not less than 0.37 kW.

## 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.

### **3.04 Manufacturer's Services**

Furnish the services of the electric door operator manufacturer's field service technician to inspect each final installation and supervise initial operation of the units. Manufacturer's certificate shall be submitted to the Engineer prior to testing the equipment. Furnish the services of the electrical door operator manufacturer's trained representative for a minimum of 1 trip of 1 day to instruct plant personnel on proper operation and maintenance procedures. Service may be combined with the inspection services specified above.

**End of Section 08365**

## 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 pit 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  $1780 \text{ n/m}^2$ .
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  $0.046 \text{ l/sec./m}$  of ventilator perimeter when subjected to a static pressure drop of  $298 \text{ n/mm}^2$  (80 km/hr.).
    - b. No water leakage shall occur during 15 minute application of  $204 \text{ litres/m}^2$  of window area under a static pressure of  $298 \text{ n/mm}^2$  (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 doorstiles 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 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, 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, that 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 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:
 

	<u>Height of Door</u>	<u>No. of Hinges</u>
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 pinnion 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 require each side of the door. Provide bolt through fixing employing counter sunk corrosion proofed bolts with cup washes 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 m<sup>2</sup> or quality q2, if more than 2.25 m<sup>2</sup>.

- 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.
- D. 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 09200

### Lath and Plaster

#### 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 Portland cement plasterwork.

##### 1.02 Quality Assurance

- A Work shall be carried out by persons skilled in plastering and rendering.
- B Finish surfaces within following tolerances and deviations.
  - 1. Finish Plaster:
    - a. Straight, true, square with adjoining work, smooth or keyed where required free from imperfections impairing appearance or performance.
    - b. Where not textured, not deviating more than 3mm from a 180mm straight edge placed anywhere on surface.
    - c. Make angles plumb and true.
  - 2. Ceilings:
    - a. Make surface of ceilings and bulkheads horizontal, vertical or sloping as applicable and level.
    - b. Do not deviate more than 5 mm from a 3 m straight edge.

##### 1.03 Submittals

- A Manufacturers' Data. Manufacturers' specifications and installation instructions for each material required, including other data to show compliance with Contract Documents.
- B Sample Panel
  - 1. Sample panels of each finish not less than 1.5 meters square, on movable frames for preliminary review.
  - 2. Sample panels shall be representative of materials, colours, textures and workmanship for the entire work.
  - 3. Acceptance will be for colour and texture only.
  - 4. For final review of each finish complete one wall or ceiling area on job site before proceeding with the work.
- C Accessories. Samples of all miscellaneous accessories as specified herein.

##### 1.04 Co-ordination

- A The work of this Section shall be co-ordinated with that of associated trades. In no case shall work requiring inspection be concealed by plaster until it has been approved by the Engineer.
- B Make all changes and adjustment of the materials of this Section necessary to accommodate the prescribed work of other Sections, including cutting and patching.



### 1.05 Delivery, Storage and Handling

- A Manufactured materials shall be delivered in original unopened packages, containers, or bundles, bearing manufacturers name and brand.
- B Store plaster, cement and lime off ground, under water tight cover, away from sweating walls and other damp surfaces, until ready for use. Remove damaged or deteriorated materials from site at first reasonable opportunity.

### 1.06 Environmental Conditions

- A Temperature and ventilation shall comply with ASTM C926 and/or BS 5492 as appropriate.
- B Ventilate building spaces as required to remove water in excess of that required for hydration of plaster. Begin ventilation immediately after plaster is applied and continue until it sets.

### 1.07 Protection

Protect all fixtures, frames, inserts and other contiguous work from rusting, soiling or clogging due to plastering.

## Part 2 Products

### 2.01 General

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 may be acceptable subject to the Engineer's approval.

### 2.02 Materials

- A Aggregates
  - 1. Portland Cement Plaster Base Coats: ASTM C 897, natural sand or BS 1199/1200 as appropriate.
  - 2. Portland Cement Plaster Finish: ASTM C 897 and either graded silica sand passing a 30 mesh screen in colour required to match Engineer's sample or gem silica sand passing a 30 mesh screen in colour required to match Engineer's sample.
- B Bonded Plaster. Bonding Agent. Provide a bonding agent composed of a resinous formulation for use in bonding plaster work to walls, columns etc. in accordance with ASTM C 631.
- C Portland Cement for all uses ASTM C150 Type I or Type II or BS12.
- D Miscellaneous Accessories
  - 1. Corner Beads shall be not less than 0.45 mm galvanized steel, formed with a bead not exceeding 5 mm, with expanded flanges at least 63 mm wide.
  - 2. Casing and stop beads shall be not less than 0.60 mm galvanized steel, formed with expanded wing unless otherwise shown.
  - 3. Metal Corner Reinforcement:
    - a. Expanded large mesh diamond lath fabricated from zinc alloy.

- b. Welded wire mesh fabricated from 1.2 mm diameter zinc coated (galvanized) wire and specially formed to reinforce external corner of Portland cement plasters on exterior exposures while allowing full plaster encasement.
4. Control Joints - Two Piece Type. Pair of galvanized steel casing beads with back flanges formed to provide slip joint action, adjustable for joint widths 3 mm to 15 mm.
5. Control Joints - One Piece Type folded pair of galvanized non-perforated screed in 'M' shape configuration, with expanded flanges.
6. Strip lath shall be expanded copper bearing steel not less than 1.36 kg/sq. m.
7. Masonry nails and screws shall be stainless steel Grade 316 L.
8. Building Paper. Bituminous water proof building paper complying with BS 1521 Grade A1.

E Water shall be potable and free from deleterious materials.

F Metal Lath

1. Shall be galvanized steel lathing having a minimum shortway aperture of 6 mm and weighing a minimum of 1.25 kg/sqm complete with a protective coating of black asphaltic paint.
2. Shall comply with BS 1369.
3. Lathing shall be mechanically fixed to masonry or concrete to the complete approval of the Engineer.

## 2.03 Mixes

A General

1. Proportions
  - a. All mixes are by volume unless otherwise specified.
  - b. All mix proportions are suggestive only, variations to meet local conditions and achieve the desired finish are permitted within the limits specified in ASTM C926 or BS 5492/5262 as appropriate.
2. Lime Putty
  - a. Make from hydrated lime; machine- mix with water to putty form.
  - b. Allow to stand at least 15 minutes before using.

B Portland Cement Plaster Mixes:

1. Base coat. ASTM C 926 or BS 5492/5262 as appropriate as follows one part Portland Cement with three to five parts natural sand and 1/4 part lime putty
2. Brown Coat. ASTM C 926 or BS 5492/5262 as appropriate as follows one part Portland Cement with three to five parts silica sand and 1/4 part lime putty.
3. Finish Coat. ASTM C 926 or BS 5492/5262 as appropriate as follows one part Portland Cement with three to five parts silica sand and 1/4 part lime putty.

## Part 3 Execution

### 3.01 Condition of Surfaces

The Contractor shall examine substrata 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 Preparation

A Acceptance of Background. Ensure the following background conditions are satisfied before applying coatings:

1. Adequately true and level to achieve specified tolerance.
2. Adequately fixed.
3. Free from contamination and loose layers.
4. Adequately prepared to give a good bond.
5. Free of any coatings of bituminous compound or any other detrimental waterproofing or damproofing agent.

#### B Preparation of Surfaces

1. Comply with ASTM C 926 or BS 5262 Para 20 for all plaster.
2. Do not apply materials to damp or wet surfaces or to concrete that is less than 6 weeks old.
3. Do not begin plastering until:
  - a. Openings, chases or other apertures required for services are formed.
  - b. Fixing for pipes, fixing pads, and plugs have been fixed.
  - c. Making good has been completed.
  - d. Cut ends of metal mesh beads etc., damaged areas of conduit, switch and outlet boxes etc. have been coated with black tar-based paint.

#### C Bonding Agents shall not be used in lieu of metal lath or wire lath for monolithic bonding of plaster to concrete ceilings or wall surfaces which require more than 10mm of plaster, to produce required lines or surfaces.

### 3.03 Installation

#### A General

1. The term "Plaster" shown on the Drawings means Portland Cement plaster unless otherwise noted.
2. Apply 2-coat work on all bases.
3. Apply finish coat with a reasonably uniform thickness over entire surface with ceilings level and with vertical surfaces flat, straight and plumb.
4. Make interior angles square, and make arises square but slightly rounded.
5. Solidly grout hollow metal frames occurring in plaster walls with plaster specified for base or brown coat.

#### B Mixing

1. Use mechanical mixers for mixing plaster.
2. Hand mixing is not permitted.
3. Do not use frozen, caked or lumped material.
4. Clean mechanical mixers, mixing boxes and tools after mixing each batch; keep free of plaster from previous mixes.
5. Thoroughly mix plaster with proper amount of water until uniform in colour and consistency.
6. Retempering not permitted; discard plaster which has begun to stiffen.
7. Provide waterproof protection under mixer.

#### C Machine Applied Plaster

1. Determine proper consistency by slump test as follows:
  - a. Take slump test samples from nozzle of plastering machine hose using a 50 x 100 x 150mm slump cone.
  - b. Samples will be taken at random as often as may be required and without prior notice.
  - c. Portland Cement Plaster: Maximum 63mm slump.

- D Method of application shall be by hand or machine application. Limit machine application to base coats, except where machine texture finish is specified.

### **3.04 Thickness of Plaster**

Portland Cement Plaster: 20 mm total.

### **3.05 Application of Portland Cement Plaster**

- A To avoid abrupt changes in the uniform appearance of the succeeding coat, each plaster coat shall be applied to an entire wall or ceiling panel without interruption. Joining of wet plaster to set plaster should be made at naturally occurring interruptions in the plane of the plaster, such as arises or wall and ceiling openings. Where this is not possible, such joining shall be cut square and straight and at least 150mm away from a joining in the preceding coat.
- B Apply Portland Cement Plaster in accordance with ASTM 926 or BS 5262/5492 as applicable.

### **3.06 Application of Miscellaneous Accessories**

- A Corner Beads
1. Provide on all external corners and arises and in single lengths where the length of a corner or arris does not exceed the standard stock lengths.
  2. Mitre or cope the beads at corners and fasten securely with tie wires, hardened galvanized nails, staples or offset head or hook head lath nails spaced not more than 200 mm staggered.
- B Casing or Stop Beads
1. Provide where shown and where plastering terminates and is not covered by other finish.
  2. Provide sheet metal closures at reveals.
  3. Set the beads level, plumb and true to line.
  4. Install in lengths as long as is practicable and align joints with concealed splice or tie plates.
  5. Secure beads with tie wire, hardened galvanized nails or other accepted methods.
  6. Space fastenings not more than 200mm apart.
- C Strip Lath. Where plaster is to be applied across differing backgrounds and over chases provide strip lath 600mm wide located centrally over joint except that where small widths of one material are involved completely bridge the one material with mesh wide enough to extend 75mm each side.

### **3.07 Application of Bonding Agent**

Apply in accordance with manufacturer's printed instructions.

### **3.08 Field Quality Control**

Plaster Sampling. Samples may be taken from work in place at any time. Areas represented by samples which show oversanding or wrong aggregate proportion will be rejected.

### **3.09 Patching**

- A Work containing cracks, blisters, pits, checks, or discoloration will not be accepted.
  - 1. Remove such work, including rejected work, and replace with new.
  - 2. Patching of defected work permitted only with the Engineer's approval.
  
- B Perform cutting, patching, repairing and pointing-up operations neatly and thoroughly.
  - 1. Repair the cracks and indented surfaces by moistening the plaster and filling with new material, troweled or tamped flush with adjoining surfaces.
  - 2. Point-up and finish surfaces around fixtures, outlet boxes piping, fittings, tile and other work flush with adjacent plaster.
  - 3. Where new plaster adjoins plaster which has been installed more than 48 hours, cut existing plaster at an angle of approximately 45 Deg. with the surface before installing new plaster.

### **3.10 Curing, Cleaning and Protection**

- A Make provisions to minimize the spattering of plaster on other work.
  
- B Promptly clean windows and other surfaces which have been soiled.
  
- C Protect plaster from the weather, premature drying, marking, dirt, dust, marring or other damage throughout the construction period so that it will be without any indication of damage at the time of Substantial Completion of the Works.
  
- D Cure plaster continuously for 15 days.
  
- E In hot weather the undercoat shall be protected to avoid rapid drying out. Polyethylene sheet to ASTM C171 shall be held against the surface to prevent evaporation.

**End of Section 09200**

## Section 09250

### Gypsum Board

#### Part 1 General

##### 1.01 Description

- A The work included in this section comprises furnishing all labour, plant, equipment, appliances and materials and performing all operations in connection with Gypsum Board installations.
- B The principle work of this section includes:
  - 1. Gypsum Board Wall Linings
  - 2. Gypsum Board Partition System
  - 3. Suspended Gypsum Board Ceiling

##### 1.02 Submittal

- A Manufacturer's specifications, installation instructions and other data to show compliance with the Contract Documents.
- B Detailed shop drawings at full scale of all unusual conditions in connection with gypsum board construction.

##### 1.03 Delivery, Storage and Handling

- A Deliver materials to project site in manufacturer's unopened bundles and containers with manufacturer's name, brand, type and grade clearly indicated thereon.
- B Store materials above grade in a dry ventilated space, under cover and in accordance with manufacturer's printed instructions. Protect from soiling or damage.
- C Avoid exposure of material to the weather by using protective covers. Handle materials to avoid damage.

##### 1.04 Environmental Conditions

Install gypsum board only when temperature, humidity and ventilation can be maintained at or above levels recommended by gypsum wallboard manufacturer.

#### Part 2 Products

##### 2.01 Materials

- A Provide gypsum board materials, including accessories and fasteners produced or recommended by a single manufacturer.
- B Gypsum Drywall Board
  - 1. 12.5 mm thick, unless otherwise shown.
  - 2. Complying with the following requirements:
    - a. Face Layer: ASTM C36, with tapered edges, Type X, unless stated otherwise.
    - b. Base Layer: ASTM C36, Type X, unless stated otherwise.

- c. Water Resistant: ASTM C630, with tapered edges.
- C For all applications of fasteners involving gypsum board comply with manufacturer's printed recommendations.
- D Joint compound, joint tape and finishing compound shall conform to ASTM C475, be asbestos-free and shall be as recommended by the gypsum drywall board manufacturer.
- E Laminating adhesive shall be of a type recommended by gypsum drywall board manufacturer.
- F Sealants shall be of a type recommended by gypsum drywall board manufacturer to produce required acoustical ratings, and refer to Section 07920.
- G Galvanized steel or plastic cornerbeads, edge trim and control joints, of sizes and profiles as recommended by the gypsum drywall board manufacturer shall be provided to suit the intended use. Trim materials, profiles and sizes shall be approved by the Engineer.
- H Structural members accessories shall be in accordance with ASTM C645. Galvanized steel studs, furring channels and runners, of type, size and gauge shall be provided as recommended by the gypsum drywall board manufacturer to suit the intended use.
- I Ties shall comply with the requirements of Underwriter's Laboratories, Inc., and the gypsum drywall board manufacturer and be either 1.2 mm tie wire or 13 mm x 0.38 mm galvanized steel strapping.
- J Acoustical insulation shall be of type and thickness as recommended by the gypsum drywall board manufacturer to produce the required acoustical ratings.
- K Water shall be potable and clean and free of deleterious material.
- L Primary Suspension Members for Ceilings
  1. Hanger inserts shall be galvanized steel flats, 25mm x 5mm with 11 mm holes on center line and lower ends with approved hanger inserts for rod hangers.
  2. Hangers shall be 5mm x 25mm galvanized steel straps or 6mm diameter galvanised rods as approved with adjustable height.
  3. Carrying channels shall be 38mm, 0.7 kg/m galvanized cold rolled steel channels.

## 2.02 Mixes

Mix joint compound in the proportions recommended by the approved gypsum drywall board manufacturer. Retempering of mix or the use of partially set joint compound will not be permitted. Allow complete breakdown of binder before use.

## Part 3 Execution

### 3.01 Condition Of Surfaces

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 have been corrected.

### 3.02 Installation

**A Framing Members**

1. Install framing members for drywall board to produce rigid flat, surfaces with supports at all edges of drywall board in accordance with ASTM C754 unless more stringent requirements are specified by the manufacturer.
2. Space metal studs at maximum 400 mm centres. Align runner tracks accurately to the partition layout as required to limit deflection to L/120 at 360 Pa.
3. Provide additional framing and blocking as required to support drywall board at openings and built-in anchorage and attachment devices for other work.

**B Gypsum Wallboard**

1. Install gypsum wallboard to produce rigid true surfaces and to comply with required sound resistance ratings accordance with ASTM C840 unless more stringent requirements are specified by the manufacturer.
2. Install maximum practical lengths of wallboard with minimum number of end butt joints. Where butt joints are necessary, stagger joints and locate as far as possible from centre of walls.
3. Install control joints as shown, and as recommended by manufacturer and as directed by the Engineer.
4. Install metal trim accurately at exposed edges, doors, and other locations as shown. Fasten trim securely.
5. Use joint compound and apply before inserting face layer into frame.
6. Cut openings in wallboard for electrical outlets, piping and other penetrations. Maintain close tolerances so that edges will be covered by plates or escutcheons.
7. Do not allow electrical outlets back to back on opposing sides of partitions.
8. Install water-resistant wallboard where shown.

**C Single Layer Application:** apply wallboard from ceiling to floor by single length of wallboard, where possible. Hold joints back at least 200 mm from corners of door frames. Space screws at not more than 400 mm centres.

**D Double Layer Application**

1. Apply on base layer on walls vertically with long joints on framing members. Space screws at not more than 400 mm centres.
2. Screw, attach or apply face layer to base layer with laminating adhesive, with joints on surface spaced 250 mm from the parallel joints in the base layer.

**E Sound Rated Partitions**

1. Provide the combination of wallboard, sealant and framing to produce the ratings shown.
2. Apply acoustical sealant at perimeters of partitions to produce the required STC ratings.
3. Provide acoustical sealant in back of control joints, around outlets boxes, and at perimeter of all cutouts to completely seal all openings and joints.
4. Install acoustical insulation where shown.
5. Form continuous layer for full height and length of partition and tightly abutting web of studs.
6. Fit carefully behind electrical outlets and other penetrations.

**F Water Resistant Drywall**

1. Use as a substrate for ceramic tile and elsewhere as shown.
2. Pre-cut panels to required size and make necessary cut-outs. Apply compound to all cut or exposed panel edges before installation.
3. In areas to receive ceramic tile finish, treat all joints and fastener heads with water resistant compound.

**G Ceilings**



1. Use only height adjustable rod hangers or strap hangers. Wire hangers are not acceptable.
2. Provide hangers and inserts necessary to support suspended ceilings below concrete slabs. Give particular attention to the correct location and alignment of hangers and inserts.
3. Frame openings so that recessed items finish flush.
4. Provide sufficient hangers for runner channels on each side of light fixtures, ceiling diffusers grilles, access panels and other items penetrating the ceiling.
5. Fasten drywall board to furring channels at not more than 300 mm centres.

#### H General Finishing Requirements

1. Fill openings around cutouts with compound or acoustical sealant as recommended by the manufacturer.
2. Reinforce all joints at tapered edges and interior corners with joint reinforcing tape set in joint compound
3. Fill all joints, fastener heads, trim recesses, cracks and other depressions with joint compound.
4. Finish smooth and flush so that joints, screws and other items will not be visible after painting.

### 3.03 Field Quality Control

Finish surfaces within 6 mm in 2.4 m for plumb, level, warp and bow.

**End of Section 09250**

## Section 09300

### Tile Work

#### Part 1 General

##### 1.01 Description

- A The work included in this Section comprises furnishing all plant, labour, equipment, appliances and materials and performing all operations in connection with ceramic and quarry tile installation.
- B The principal work of this Section includes, but may not be limited to, the following:
  1. Ceramic tiles to walls.
  2. Ceramic tiles to floors.
  3. Quarry tiles to floor

##### 1.02 Qualifications

Executed by a firm having a minimum of five years experience in the installation of materials specified herein on projects comparable to this Project.

##### 1.03 Submittals

- A Manufacturer's product data, including installation instructions, use, limitations and recommendations. Provide certifications stating that materials comply with requirements.
- B Duplicate samples for each tile type shall be provided each consisting of four tiles mounted on rigid panel board including grouted joints. The Engineer's acceptance shall be for colour, pattern, texture and joint width only. Compliance with other requirements is the responsibility of the Contractor.
- C Shop drawings shall be provided for installation and erection of all parts of the work. The Contractor shall include plans, elevations and details where tiles terminate and at meeting of floor and walls; details of control and explanation joints. Field measurements shall be taken before submitting shop drawings.

##### 1.04 Delivery, Storage And Handling

- A Deliver, store and handle materials and products in a manner to prevent damage. Deliver materials and products in unopened factory labeled packages indicating the name, brand, type, class, size and colour. Sequence deliveries to avoid project delays and to permit proper co-ordination of the work.
- B Store and handle in strict compliance with manufacturer's instructions and recommendations. Replace damaged items with no change in Contract price.

##### 1.05 Co-ordination

- A Completely co-ordinate the work specified in this Section with all other work. Verify field dimensions and condition of work which adjoins material of this Section. Notify the Engineer of deviations from the Contract Documents before proceeding with the work specified in this Section.

- B Commence work only after grounds, anchors, plugs, hangers, bucks, electrical and mechanical work which are to be in or behind tile work are installed.

### 1.06 Quality Assurance

- A Method of installation of tiles shall be in strict accordance with manufacturer's recommendations.
- B Obtain each material required for any one type and colour of the work from a single source, so as to minimise variations in appearance and quality.

### 1.07 Extra Stock

Deliver to Employer at his specified store two unopened boxes of each type and colour of tile installed.

## Part 2 Products

### 2.01 Materials

- A Products and manufacturers specified hereinafter are specified for the purposes of establishing minimum quality standards.
- B Products which are equal to, or better than, those specified and which conform to the Engineer's design requirements and colour selections, may be acceptable subject to the Engineer's approval.

### 2.02 Ceramic Tiles

- A Conform to BS 6431 or DIN 18166.
- B Average water absorption  $\leq 3$  percent.
- C To be acid and alkali resistant.
- D Average Compressive Strength not to be less than 20 N/mm<sup>2</sup>.
- E Suitable for heavy duty purposes as recommended by the manufacturer for similar building types.
- F Tiles shall be selected from a range as manufactured by Buchtal Ceramic Works, West Germany, or other equal and approved.
- G Ceramic tiles shall be of the following types as designated below of sizes shown on the Drawings or specified herein and of colours as selected by the Engineer.
  - 1. Wall Tiles
    - a. Size 240 X 115 X 6 mm thick glazed.
    - b. Provide tile trim shapes as required to suit the installation.
  - 2. Floor Tiles
    - a. Size 115 x 115 X 8 mm thick unglazed.
    - b. Provide tile trim shapes as required to suit the installation.

### 2.03 Tile Accessories

- A Metal edge strip shall be shaped, finished and anchored as shown.
- B Trim Shapes
  - 1. Shapes as shown for typical conditions, and as required to make a complete installation at all conditions.
  - 2. Match type, class, colour and edge of adjoining field units.
  - 3. Co-ordinate sizes with field units.

#### **2.04 Quarry Tiles**

- A Quarry floor tiles shall be 150 X 150 mm of approved pattern and colour.
- B Coved skirting to match tiles shall be 150 mm high with bull nose top and cove at bottom. Internal angles and rounded external angles.

#### **2.05 Setting Materials**

- A Portland Cement shall be ASTM C 150 Type I or BS12, white where required.
- B Pigments
  - 1. Pure mineral pigments.
  - 2. Resistant to alkalis.
  - 3. Non-fading.
  - 4. Weatherproof.
  - 5. Colours as required and approved by the Engineer.
- C Water shall be potable and clear and without deleterious substances.
- D Sand shall be to ASTM C 144 or BS 1199/1200.

#### **2.06 Mortars and Grouts**

- A Latex Mortar Setting Beds
  - 1. One part Portland cement with three parts sand mixed dry and then gauged with a sufficient quantity of liquid latex additive No. 3701 (Laticrete International).
  - 2. Amount of gauging liquid required and the consistency of cement setting bed for using a dry tamp method shall be as recommended by the manufacturer of the liquid latex additive.
- B Liquid Latex Mortar (Thin Set)
  - 1. "Laticrete 4237 Liquid" as manufactured by Laticrete International and Portland Cement.
  - 2. Mixed in the ratio of 2.25 kg. Portland cement to 1 litre "Laticrete 4237 liquid" unless otherwise recommended by liquid latex manufacturer.
  - 3. Addition of fine sand to cement shall be only as necessary for filling rough surfaces and as recommended by the liquid latex manufacturer.
  - 4. Use of the above is required for all thin set applications and as slurry bond coats at mortar and bed applications.
- C Grout for non-vitreous tiles shall have colour as shown or as required, gauged with "Laticrete 3701 grout admix".

- D Grout for vitreous tiles shall have colour as shown or as required, gauged with “Laticrete 3701 grout admix”.
- E Tile adhesive shall be water-resistant complying with ANSI A 136.1 and as recommended by the tile manufacturer to suit the type of application.
- F Chemical resistant tile grout shall be as recommended by the tile manufacturer and approved by the Engineer.

## 2.07 Sealant

Sealant for tiles shall be based on silicone type recommended for tile work as manufactured by Dow Chemical, General Electric or other equal and approved. Colour to match adjoining tile colour.

## Part 3 Execution

### 3.01 Condition of Surfaces

- A Thoroughly examine all surfaces to receive work of this Section, and notify Engineer in writing of all conditions which would adversely affect this work.
- B Do not commence work in any area where such notice of adverse conditions has been sent to the Engineer, until corrective work has been completed or waived.
- C Starting of work in any area without issuance of such notice should constitute acceptance of conditions in the area by the Contractor who shall be responsible for the satisfactory results of his work. Any defects occurring thereafter shall be corrected without additional charge to the Employer.
- D Allow slabs to dry adequately before applying materials. At the direction of the Engineer, perform simple calcium-chloride test to ensure concrete surfaces are free of contained moisture.
- E Fill all cracks in sub-surfaces using approved crack-filler in accordance with manufacturer's printed instructions.
- F Clean subfloors of all remaining dirt and loose particles before application of flooring materials.
- G Underlayment used to correct floor slabs with surfaces not constructed to specified tolerances shall be provided as part of the work in Section 03300. Small dips and minor imperfections on the floor surface shall be corrected using specified latex levelling mortar as part of the work under this Section at no additional cost to the Employer.
- H Allowable Variations in Substrata Levels:
  - 1. Mortar Set Floors: 1/500 distance and 9 mm total maximum variation from levels shown.
  - 2. Mortar Set Walls and Ceilings: 1/400 distance and 6 mm total maximum variation from planes shown.
- I Thin-Set Work: same as allowable variation in finished work.

### 3.02 Preparation

- A Etch substrata with 10percent solution of muriatic acid as may be required to remove curing compounds or other substances that would interfere with proper bond of specified mortar for tiles.
- B Rinse with water to remove all traces of acid.
- C Seal substrata with sealer as recommended by manufacturer of mortar.

### 3.03 Installation

- A Unless otherwise shown or specified comply with applicable requirements of:
  - 1. ANSI A 108.1 through A 108.6, ANSI 137.1.
  - 2. Recommendations of TCA, "Handbook for Ceramic Tile Installation".
- B Comply with the manufacturers' instructions for the installation of each material required.
- C Tile applicator shall install all tiles using lighting conditions that will represent the proposed lighting required in the areas involved. Requirement will be insisted upon in order to achieve uniformity in laying out tiles.
- D Tiles shall be applied to full wall areas where mirrors and surface mounted accessories are to be installed.
- E Surfaces to receive tile finish shall be clean and free of all foreign matter detrimental to the bond.
- F Room temperatures at areas in which tile materials are being installed shall be maintained at not less than 5°C for a period of twenty-four hours prior to commencement of work, during work, and afterwards until completion of construction. Areas in which tile work is being done shall be closed to traffic until the installation has set.
- G Lay out work so that no tile less than half size occurs
  - 1. Align joints in floor tile at right angles to each other and straight with walls to conform to patterns selected.
  - 2. Verify locations of accessories before installing tile.
  - 3. Co-ordinate with plumbing and other trades.
- H Allowable Variations in Finished Work
  - 1. Do not exceed the following deviations from level and plumb and from elevations, locations, slopes and alignments shown:
    - a. Floors: 1/1000 run, any direction; +/- 3 mm at any location; 0.8 mm offset at any location.
    - b. Walls: 1/800 run, any direction; +/- 3 mm at any location; 0.8 mm offset at any location.
    - c. Joints: +/-0.8 mm joint with variation at any location; 1/600 run for deviation from plumb and true; and for other variations in alignment of joints.
- I Lay out tile work in pattern shown using field tile and trim shapes as shown.
  - 1. Centre tile fields both directions in each space or on each wall area and adjust to minimise tile cutting.
  - 2. Use uniform joint widths for ceramic tile and for quarry tile unless otherwise shown or approved. Cut field tile, not trim shapes, unless otherwise shown.

- J Extend tile work into recesses and under equipment and fixtures in the spaces shown or scheduled to receive tiles.
  - 1. Form a complete covering without interruptions except for control and expansion joints and as required to comply with requirements.
  - 2. Terminate work neatly at obstructions, edges and corners without disruption of pattern or joint alignments.
- K Use liquid latex mortar for thin-set tile work, unless otherwise shown.
- L Latex Mortar Setting Beds for Quarry Tiles
  - 1. Install quarry tiles over latex mortar setting beds with a slurry bond coat of Liquid Latex Mortar as hereinbefore specified.
- M Use appropriate adhesive for setting tiles where adhesive installation is shown.
- N Non-Slip Tile Installation
  - 1. Use non-slip tiles in areas shown as "Non-Slip".
  - 2. Install as specified for normal ceramic tiles of the same type and class.
- O Install a continuous stainless steel edge strip adequately anchored into the substrata where shown or where exposed edge of ceramic tile flooring meets carpet or other soft floor covering.
- P Provide control joints or expansion joints where shown or required by ANSI or TCA standard or by job condition for proper workmanship.
  - 1. Install removable divider strip of proper width and depth of the tile and setting bed.
  - 2. Remove strips after grouting tiles and properly curing the work.
  - 3. Install joint fillers and sealants, in control joints and expansion joints, of type as recommended by the tiling manufacturer.

### **3.04 Grouting**

- A Do not commence grouting for at least 24-hours after placing of tile.
- B Follow specific instructions of listed standards.
- C Mix and apply in strict accordance with manufacturer's instructions.
- D Grout wall and floor tiles with indicated grout mixed to a workable stiff consistency in accordance with manufacturer's directions.
- E Force maximum grout into joints with trowel or squeegee.
- F Before grout sets, strike or tool joints to base of cushion and fill all skips and gaps.
- G Do not permit setting bed materials to show through grouted joints.
- H Cure grout joints by maintaining damp condition.

### **3.05 Sealant Application**

- A Apply silicone sealant in joints where ceramic tile terminates at thresholds, floor drains, control joints in walls and other areas indicated.

- B Co-ordinate with trades affecting these items.
- C Application of sealant shall conform to applicable requirements set forth under Section 07920. Requirements therein shall become a part of the work under this Section as though written out in full herein.

### **3.06 Cleaning and Protection**

- A After tile has thoroughly set, sponge and wash tile thoroughly and diagonally across joints.
- B Remove all surface cement and take care not to damage tile or adjacent materials.
- C Do not use acid cleaners.
- D Finally, clean all tiles using dry cloths.
- E Remove from the site and legally dispose of at the end of each day, all cartons, rubbish and debris resulting from the work of this Section.
- F Protect tiles after cleaning with non-staining heavy Kraft paper or other approved coverage until acceptance of the building by the Employer.

### **3.07 Maintenance Literature**

Upon completion of all work specified herein, the Contractor shall furnish to the Employer, literature on the "Care of Ceramic and Quarry Tiles" for future maintenance use.

**End of Section 09300**



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## Section 09420

### Precast Terrazzo

#### 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 precast terrazzo floor tiles

##### 1.02 Qualifications

The terrazzo work shall be performed by a firm having five years experience in the installation of materials specified herein on projects comparable to this Project.

##### 1.03 Submittals

- A Manufacturer's specifications and installation instructions for each material, to show compliance with the Contract Documents.
- B Three samples of each of the tiles and 300 mm long divider strips. Samples shall be reviewed for colour, pattern and texture only.
- C Shop drawings showing large scale details of layout, jointing and edge conditions, and showing plans for layout of work including details of anchorage and other special features required including control and expansion joints.

##### 1.04 Delivery, Storage and Handling

Deliver materials in manufacturer's unopened containers, fully identified with trade name, grade and colour. Store materials above grade, protected from the weather, soiling or damage from any source and in accordance with manufacturer's instructions.

##### 1.05 Co-ordination

Completely co-ordinate the work specified in this Section with all other work. Verify field dimensions and condition of work which adjoins material of this Section. Notify the Engineer of deviations from the Contract Documents before proceeding with the work specified in this Section. Commence work of this Section only after work of other Sections, to be covered by terrazzo tiles, has been installed.

#### Part 2 Products

##### 2.01 Precast Terrazzo Units

- A Conform to BS 4131 and units shall be as follows:
  - 1. Tiles - 250 x 250 x 25 mm thick; or 300 x 300 x 30 mm thick.
  - 2. Skirtings - 250 x 100 x 20 mm thick.
  - 3. Wall strings – min. 100 mm wide x 20 mm thick cut into profile of treads and risers.
  - 4. Tread and riser units shall be one piece construction as shown on the Drawings.

- B Terrazzo units shall be formed on hydraulic presses.
- C Face section of terrazzo units shall consist of:
1. Portland Cement conforming to ASTM C-150 Type I or BS 12.
  2. Nonstaining white marble chips.
  3. Selected natural aggregate (clean and free of all impurities).
  4. Background cement and colours.
  5. Aggregate proportion shall be not less than 70 percent selected aggregate and 30 percent matrix.
  6. No aggregate with a value below Ha 10 as tested for abrasion resistance in accordance with ASTM C-241 shall be used.
- D Back or underlaying section of terrazzo units shall consist of Portland Cement and coarse sand. Back section shall have a cement/sand ratio of 1:3.
- E Terrazzo units shall be compressed to produce the exact size as per drawings with square, flush edges. Compressive strength shall be minimum of 27.5 N/mm<sup>2</sup> when tested in accordance with ASTM C-150 after curing for one day in moist air and 6 days in water.
- F Water absorption shall comply with the following requirements when tested in accordance with Appendix 'A' of BS 4131.
1. Tile face: No single results shall be more than 0.4 g/cm<sup>2</sup>.
  2. Total absorption: No single result shall be more than 8 percent.
- G Transverse strength shall comply with the following requirement when tested in accordance with Appendix 'B' of BS 4131. No single result shall be less than 3 N/mm<sup>2</sup>.
- H Marble chips shall be natural sound marble chips without flats or flakes of sizes and colours necessary to match sample.
- I Cement, sand and water shall be as specified in paragraph 2.02.

## 2.02 Setting Materials

- A Standard brand of Portland Cement, conforming to current ASTM C-150, Type I or BS 12.
- B Sand shall be clean, sharp, durable bank sand, free from silt, loam, clay, soluble salts and/or vegetable matter; shall conform to ASTM C-144 or BS 1199/1200; and be graded fine-to-coarse within the following limits:
- | <u>Sieve No.</u> | <u>% by wt Passing</u> |
|------------------|------------------------|
| No. 8            | 100                    |
| No. 16           | 90-100                 |
| No. 30           | 60-90                  |
| No. 50           | 25-55                  |
| No. 100          | 0-15                   |
- C Water shall be potable and clean, free from oils, acids, alkalis, organic and other injurious matter.

## 2.03 Additional Materials

- A Metal divider strips shall be white alloy or zinc alloy, 3 mm thick top angle shape approved by the Engineer and overall depth shall suit conditions of the job.

- B Cleaning solution shall be specially prepared neutral chemical terrazzo cleaner that will not change colour of terrazzo or damage it in any way.
- C Terrazzo sealing compound shall be penetrating type, free from harmful alkali or acid content. The sealer shall be specially prepared for the terrazzo trade and shall not yellow terrazzo or leave tacky finish on surface after buffing.

## **2.04 Mortars and Grouts**

Mix bedding mortar in accordance with Tile Council of America Specifications for Conventional Cement Mortar and ANSI A108.1, 1976. Mortar bed mix shall be one part Portland Cement, 6 parts damp sand and up to 1/10 part hydrated lime by volume. When mixed with water, the mortar shall be of such consistency and workability to allow maximum compaction during tamping of mortar bed. Grout shall be inorganic Portland Cement dry curing grout, ready to use with addition of water. Colour of grout shall be selected by the Engineer.

## **Part 3 Execution**

### **3.01 Condition of Surfaces**

- A The Contractor shall thoroughly examine all surfaces to receive work of this Section, and shall notify Engineer in writing of all conditions which would adversely affect this work. Work shall not commence in any area where such notice of adverse conditions has been sent to the Engineer, until corrective work has been completed or waived.
- B Starting of work in any area without issuance of such notice should constitute acceptance of conditions in the area by the Contractor who will be responsible for the satisfactory results of his work. Any defects occurring shall be corrected without additional charge to the Employer.
- C Slabs shall be allowed to dry adequately before applying materials. At the direction of the Engineer, simple calcium-chloride tests shall be performed to ensure concrete surfaces are free of contained moisture.
- D All cracks in sub-surfaces shall be filled using approved crack-filler in accordance with manufacturer's printed instructions.
- E Subfloors shall be cleaned of all remaining dirt and loose particles before application of flooring materials.
- F Underlayment used to correct floor slabs with surfaces not constructed to specified tolerances shall be provided as part of the work in Section 03300. Small dips and minor imperfections on the floor surface shall be corrected using specified latex levelling mortar as part of the work under this Section.
- G Allowable variations in substrata levels for mortar set floors shall be 1/500 distance and 9 mm total maximum variation from levels shown.

### **3.02 Preparation**

Substrata shall be etched with 10 percent solution of muriatic acid as may be required to remove curing compounds or other substances that would interfere with proper bond of

specified mortar for tiles and rinsed with water to remove all traces of acid. Substrata shall be sealed with sealer as recommended by manufacturer of mortar.

### 3.03 Installation

- A The manufacturers' instructions shall be followed for the installation of each material required. Tiles shall be installed using lighting conditions that will represent the proposed lighting required in the areas involved. The requirement will be insisted upon in order to achieve uniformity in laying out tiles.
- B Room temperatures at areas in which tile materials are being installed shall be maintained at not less than 5°C for a period of twenty-four hours prior to commencement of work, during work, and afterwards until completion of construction. Areas in which tile work is being done shall be closed to traffic until the installation has set.
- C Work shall be laid out so that no tile less than half size occurs. Joints in floor tiles shall be aligned at right angles to each other and straight with walls to conform to patterns selected. Locations of accessories shall be verified before installing tiles and shall be co-ordinated with plumbing and other trades.
- D Do not exceed the following deviations from level and plumb and from elevations, locations, slopes and alignments shown:
  - 1. Floors: 1/1000 run, any direction; +/- 3 mm at any location; 0.8 mm offset at any location.
  - 2. Joints: +/-0.8 mm joint with variation at any location; 1/800 run for deviation from plumb and true; and for other variations in alignment of joints.
- E Tile work shall be extended into recesses and under equipment and fixtures in the spaces shown or scheduled to receive tiles to form a complete covering without interruptions except for control and expansion joints and as required to comply with requirements. Work shall be terminated neatly at obstructions, edges and corners without disruption of pattern or joint alignments.

### 3.04 Application Over Conventional Mortar Bed

- A Mortar bed shall be mixed and applied in accordance with Tile Council of America Specifications for conventional Cement Mortar and ANSI A108.1.
  - 1. Apply the mortar bed with reinforcing mesh over entire area.
  - 2. Mortar mix shall be of such consistency or workability as to promote maximum density, determined by stroking of mortar surface with a trowel.
  - 3. When of correct consistency, the trowelled surface readily assumes a smooth, slickened appearance.
  - 4. Screed and tap mortar bed firmly.
  - 5. Mortar beds shall be in thickness required, determined by the depression.
  - 6. Any required pitch which is not already in the slab must be provided in the mortar bed.
- B While the mortar bed is still fresh but stiff enough to set tile, tiles shall be set as follows:
  - 1. Trowel or brush a thin layer 1 mm to 1.5 mm in thickness, of neat Portland cement paste over the bed and/or the back of tile.
  - 2. Press tile firmly into the bed, tamping with wood blocks to obtain smooth surface.
  - 3. All tiles shall be aligned properly with straight joints in even widths.
  - 4. Tamping shall be completed within one hour after placing tile.
  - 5. Adjusting work out of line shall be done within the one hour period.

6. Refer to drawings for location of expansion joints. All such joints shall be clear of grout to receive sealant.

### **3.05 Control Joints at Exposed Locations**

- A Setting beds shall be cut through at perimeter joints and at projections through the floor. Nooprene or butyl rubber strip (Shore A Hardness 70) shall be installed full depth of setting bed and caulking of joints with approved pouring grade sealant will be done under Section 07920.
- B Control joints shall be provided where floor tiles meet restraining surfaces such as perimeter walls, cove bases, curbs, columns, pipes, etc. Control joints shall not exceed 10 m centre to centre each way in floors, located as directed by Engineer. Control joints shall be formed in neat, straight lines and tiles shall be cut cleanly and to accurate radius at exposed junctions with pipes, etc. Control joints shall be same width as grouted joints, but not less than 6 mm.
- C Control joints that will be exposed in the finished work shall be filled to full depth of setting beds from sub-surface to rear face of tile, with control joint backing. The remaining void shall be kept clear of grout and debris. After completion of grouting operations, control joint sealant of colour to match adjoining grout will be applied under Section - 07920.

### **3.06 Divider Strips Installation**

White alloy or zinc divider strips of 3 mm wide shall be provided and adequately anchored into the substrata at 2 m centres in both directions and between terrazzo tiles and dissimilar floor finishes where thresholds do not occur. Where divider strips are located across door openings, strips shall be located on the door side, in line with the edge of doorstop, terminating at the rebate.

### **3.07 Grouting**

Grouting shall not commence for at least 24 hours after placing of tiles and shall follow specific instructions of listed standards and be applied in strict accordance with manufacturer's instructions.

### **3.08 Cleaning and Sealing**

- A After tiles have thoroughly set, they shall be sponged and washed thoroughly and diagonally across joints. All surface cement shall be removed taking care not to damage tile or adjacent materials. Acid cleaners shall not be used.
- B As soon as terrazzo surfaces are thoroughly dry, sealer shall be applied. Sealing shall be done in strict accordance with manufacturer's directions, leaving a polished surface approved by the Engineer.

### **3.09 Protection and Clean Up**

- A Tiles shall be protected after cleaning and sealing with non-staining heavy Kraft paper or other approved coverage. Torn or worn papers shall be replaced until acceptance of the building by the Employer.

- B All cartons, rubbish and debris resulting from the work of this Section shall be removed from the site and legally disposed of at the end of each day.

### **3.10 Maintenance Literature**

Upon completion of all work specified herein, the Contractor shall furnish to the Employer, literature on the "Care of Terrazzo" for future maintenance use.

**End of Section 09420**

## Section 09510

### Suspended Ceilings

#### 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 suspended ceilings and accessories. The principal work of this Section includes, but may not be limited to, suspended mineral fibre acoustical ceiling and suspended linear metal ceilings.

##### 1.02 Qualifications

The acoustical ceilings work shall be performed by a firm having five years experience in the installation of materials specified herein on projects comparable to this Project and shall be carried out by experienced tradesmen who are capable of producing work of the highest standard of quality in the industry.

##### 1.03 Performance/Design Criteria

Ceiling assemblies shall be provided to achieve the fire-resistance classification or rating as required and shall comply with the material and installation requirements of the UL "Building Materials Test" and other referenced guides for the UL design numbers corresponding with the construction systems shown.

##### 1.04 Submittals

- A Manufacturer's specifications and installation instructions for each material, to show compliance with the Contract Documents.
- B Three sets of full sized samples of each of the acoustical material specified. One metre lengths of linear metal and 300 mm lengths of exposed tees and mouldings. Each set of samples shall show the full range of texture and colour to be expected in the completed work. The Engineer's acceptance will be for colour and texture only and compliance with all other requirements is the exclusive responsibility of the Contractor.
- C Detailed shop drawings, including reflected ceiling plans of acoustical ceilings, before proceeding with work showing locations of all items of work which are to be coordinated with the acoustical ceilings, or to be supported by the acoustical ceiling system, and giving details in suitably large scales, all edge conditions, fixing details and accessories.
- D Manufacturer's specifications and installation instructions for acoustical material, suspension system and other products required.
- E Certified laboratory test reports and other data as may be required to show compliance with the Contract Documents.

##### 1.05 Mock-Up

The Contractor shall provide a 3 x 3 m mock-up of each type of acoustical ceiling in spaces within the building to be designated by the Engineer, including all services outlets such as



sprinklers, supply and return air grilles and lighting fixtures, etc. The mock-up shall be representative of the finished work in all respects and may, when approved, form part of the permanent work.

#### **1.06 Delivery, Storage and Handling**

- A Deliver materials to the project site in manufacturer's unopened containers, clearly indicating manufacturer's name, brand, type, style, size, colour, texture and all other identifying information.
- B Store materials in a dry location, off the ground and in a manner to prevent damage, deterioration and intrusion of foreign matter.
- C Replace materials which have been damaged, or are otherwise unfit for use, as directed.

#### **1.07 Environmental Conditions**

Acoustical materials shall not be installed unless temperature and humidity conditions closely approximate to the interior conditions which will exist when the building is occupied. Temperature and humidity conditions shall be maintained before, during and after installation. Plastering, concrete and tiling work (including grinding) shall be complete and dry and windows and doors shall be in place and glazed.

#### **1.08 Extra Stock**

Provide 1 percent of installed quantity of each type of acoustic tile to the Employer's store where directed.

## **Part 2 Products**

### **2.01 Materials**

Material type and face size shall be as shown with the following minimum characteristics:

1. Light Reflectance: ASTM C 523, 0.75 or more.
2. Flame Spread: ASTM E 84, Flame Spread 25 or less.
3. Sound Absorption: ASTM C 423, NRC not less than 0.65.
4. Sound Transmission Class: ASTM E 90, not less than 35.
5. Suspension System: ASTM C 635, Heavy Duty Classification.

### **2.02 Aluminium Ceiling and Panel Ceiling**

Aluminium panels shall be:

1. Easily removable 600 x 600 mm aluminium alloy
2. Finished with primer and top coat with acoustic quality and fire resistant
3. Colour selected by the Engineer

### **2.03 Gypsum Ceiling**

As specified in Section 09250.

### **2.04 Primary Suspension Members**

- A Hanger inserts shall be galvanised mild steel flats, 25 x 5 mm with 11 mm holes punched on centre line and lower ends for strap hangers. Manufacturer's appropriate hanger inserts

for rod hangers and the system shall be designed to develop the full strength of the type of hangers used.

- B Hangers shall be galvanised steel strap hangers 25 x 5 mm or 6 mm diameter galvanised steel rod hangers with facility for length adjustment to achieve accurate levelling.
- C Carrying channels shall be galvanised cold rolled steel channels 38 x 25 mm, 0.7 kg/m.

## **2.05 Trim**

Metal wall mouldings shall be roll formed steel with manufacturer's standard baked-on white enamel coating to match finish of acoustical material.

## **2.06 Acoustic Tile System**

- A Exposed grid mechanical suspension system for acoustic tiles shall be the manufacturer's standard design system complying with ASTM D 635 Structural Classification "Heavy Duty". The system shall be complete with hangers, main tees, cross tees, splices, angle moulding, hold down clips and accessories as required and shall include components as follows:
  1. Main tees shall be 38 x 25 mm wide formed of 0.63 mm galvanised cold-rolled steel section and bottom flange and faced with a roll formed galvanised steel cap. They shall be capable of supporting lighting fixtures and acoustical ceiling tile with maximum deflection not to exceed 1/360 of span between hangers or other supports.
  2. Cross-Tees shall be 38 x 25 mm wide formed of 0.63 mm galvanised cold-rolled steel with double web bulb tee section and bottom flange and faced with a roll formed galvanised steel cap. Web ends of cross-tees shall be die formed for the tablock attachment to adjoining tee through the main tee, to provide alignment with a minimum of torsional movement and lateral displacement.
  3. Accessories shall be galvanised steel, specifically designed for use with the main components.
  4. All rolled formed parts shall be chemically cleaned, electro-galvanised and bonderised and finished with a white baked-on enamel coating, to match finish of acoustic tiles unless otherwise shown.

## **2.07 Metal Systems**

Suspension system for metal units shall be the manufacturer's standard system complete with edge trim of Hunter Douglas Limited or approved equal.

# **Part 3 Execution**

## **3.01 Condition of Surfaces**

The Contractor shall examine the substratas 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 in a manner acceptable to the Engineer.

## **3.02 General Requirements For The Installation Of Acoustical Systems**

- A Verify all measurements and dimensions at the project site.

- B Co-ordinate the work with the work of other trades, with particular attention given to the work of mechanical and electrical trades.
- C Install all materials and systems in accordance with manufacturer's printed instructions unless otherwise shown or directed.
- D Make all exposed surfaces of acoustical units level and flush with all joints straight and true. Neatly cut and fit units around light fixtures and around other items protruding through acoustical ceilings. Install all exposed members with flush hairline joints.
- E Factory drill acoustic tile occurring at hidden loud-speakers and fire alarm gongs.
- F Centre tile or board pattern both directions in each major space or room as shown or directed and where possible adjust pattern so that edge pieces will be not less than 1/2 unit in width.
- G Run grain of units in one direction, as shown or directed and align joints in both directions unless otherwise shown.
- H Use procedures that will minimise damage or soiling of the units during installation.
- I Replace units which are damaged or cannot be adequately cleaned as directed.

### **3.03 Installation of Mechanical Suspension System, General**

- A Install primary suspension members and mechanical suspension system in accordance with manufacturer's instructions to support required loads. Prevent deflection in excess of 1/360 of the span. Spirit level accurately in both directions.
- B Co-ordinate spacing of hangers, carrying channels, runners and moulding with the location of electrical fixtures and other items occurring in or on the ceiling.
- C Comply with the requirements of ASTM C 636 and the following:
  - 1. Attachment device locations shall be co-ordinated to final layouts.
  - 2. Hangers shall be spaced not more than 150 mm from each end and not more than 100 mm o.c. between ends of members to be supported. Provide additional hangers for support of fixtures and other items to be supported by the ceiling suspension system, as required to prevent eccentric deflection or rotation of supporting runners. Provide necessary bracing and supports to allow for irregular stresses imposed on the suspension system by any mechanical ductwork connection to air handling fixtures.
  - 3. Provide mouldings where ceilings meet walls, partitions and other vertical elements. Provide mitre cut inside and outside corners.
- D Co-ordinate spacing of hangers and other suspension members with the location of electrical fixtures and other items occurring in or on the ceiling. Provide additional members or heavier members where necessary to suit interferences.

### **3.04 Installation of Acoustic Tile, Exposed Grid System**

Install tiles with edges resting on flanges of tees. Cut and fit tiles neatly against abutting surfaces. Support edges by wall mouldings. Install wall mouldings continuously where tile abuts other material and at wall intersections where tile terminates, except as otherwise detailed. Align mouldings accurately and fasten securely to constructions.

### **3.05 Installation of Linear Metal Ceilings**

- A Install linear metal ceilings and secure to the suspension system in the manner recommended by the manufacturer,
- B Maintain straight joint lines.
- C Install wall mouldings continuously where ceiling abuts other material and at wall intersections where ceiling terminates, except as otherwise detailed. Align mouldings accurately and fasten securely to constructions.

### **3.06 Cleaning and Protection**

Upon completion of the work remove all unused materials, debris, containers and equipment from the project site. Clean and repair surfaces that have been stained, marred or otherwise damaged. Protect acoustical ceilings during the construction period to prevent damage. Replace damaged units with new.

**End of Section 09510**

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## Section 09650

### Resilient Flooring

#### Part 1 General

##### 1.01 Description

The work included in this section comprises furnishing all labour, plant, equipment, appliances and materials and performing all operations in connection with Resilient Flooring.

##### 1.02 Submittal

- A. Manufacturer's specifications and installation instructions for each material, to show compliance with the Contract Documents.
- B. Three samples of each of the tiles of colours selected by the Engineer and for the resilient base 600 mm long sample of each type and colour. Samples shall be reviewed for colour, pattern and texture only.
- C. Shop drawings showing large scale details of layout, jointing and edge conditions, and showing plans for layout of work including control and expansion joints.

##### 1.03 Delivery, Storage and Handling

Deliver materials to job site in manufacturer's unopened containers clearly marked with manufacturer's name, brand, size, thickness, grade, colour and design. Store materials as per manufacturer's recommendations.

##### 1.04 Environmental Conditions

Maintain temperature in spaces receiving resilient flooring at 21° C, minimum at least 48 hours before, during, and after installation.

#### Part 2 Products

##### 2.01 General

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, may be considered acceptable subject to the Engineer's approval.

##### 2.02 Materials

- A. Primers and adhesives for resilient flooring and base shall be of a type recommended by the manufacturer and best suited for the purpose.
- B. Resilient bases (VB) shall be smooth finish FS SS-W-40, type II (vinyl) including premoulded outside corners and end stop units and unless otherwise shown, provided with bases 100 mm high set-on-cover type and straight type as required. Bases shall be minimum 1.2 m lengths and shall be of colours as selected by the Engineer.

- C Synthetic rubber (VET) shall be manufactured by Nora-Freudenberg, Weinheim, Germany or approved equal and in colours as selected by the Engineer.
- D Floor tiles shall be 600 X 600 X 3 mm; Noraplan-Homogen, Article No. 243.

## **Part 3 Execution**

### **3.01 Condition of Surfaces**

The Contractor shall examine substrate, adjoining construction, and the conditions under which the work is to be installed. Work shall not proceed until unsatisfactory condition detrimental to the purpose and timely completion of the work have been corrected.

### **3.02 Preparation**

- A Clean substrate to remove deleterious substrate which would impair the work.
- B Fill cracks, holes, and depressions in the substrate. Surfaces shall be smooth, level and at proper elevation, and shall not vary more than 1:900 in any direction from level, plumb or slopes shown. Remove roughness and protrusions from concrete surfaces by grinding. Use compounds for filling complying with resilient flooring manufacturer's recommendations.
- C Prime, seal or cover substrate if it is of a kind or in a condition which the manufacturer of the resilient flooring recommends to be primed, sealed or covered. Use materials complying with manufacturer's recommendations.
- D Test concrete floors to ensure that they are dry before installation of resilient flooring.

### **3.03 Installation**

- A Install resilient flooring in accordance with the manufacturer's printed instruction and recommendations.
- B Apply primer to concrete surfaces and work well into surface. Use minimum quantity that will assure complete surface coverage with a non-absorptive base. Allow primer to dry before applying adhesive. Prime coat may be omitted if recommended by resilient flooring manufacturer.
- C Adhesive shall be applied to substrate with properly notched steel trowels and shall become tacky before applying resilient flooring.
- D Extend resilient flooring into
  - 1 Closets and offsets.
  2. Under movable equipment of the rooms.
  - 3 Spaces shown or scheduled to receive resilient flooring, including recessed covers within those spaces.
  - 4 Extend unexposed edges of flooring under set-on bases and similar trim work.
  - 5 Scribe, cut and fit exposed edges of flooring and base adjoining other work accurately and neatly with a tight joint.
- E Tile units shall be laid symmetrically about center line of major room or space in a square pattern, unless otherwise shown and adjusted so edge units are not less than one-half of tile width. Tile units shall be laid with bottom surface securely bonded to

substrate and top surface left smooth, clean and free from imperfections. Tiles shall be fitted tightly so each unit is in contact with surrounding tiles and joints in proper alignment. Neat tight joints shall be formed where exposed edges abut other surfaces. Tiles shall be aligned with graining running in one direction and joints in both directions shall be in a square pattern unless otherwise shown.

- F Resilient bases shall be secured to surfaces with water proof adhesive, with joints tight and with top and bottom edges in firm contact with adjacent surfaces. The longest lengths possible shall be used and angles and corners shall be mitred or coped.

### **3.04 Cleaning and Protection**

Just prior to Substantial Completion of the Works, clean the resilient flooring and base. Wash thoroughly with a cleaner recommended by the flooring manufacturer, in accordance with his recommendations. Protect tiles after cleaning with non-staining kraft paper or other approved coverage until acceptable of the building by the Employer.

**End of Section 09650**



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## Section 09700

### Special Floorings

#### Part 1 General

##### 1.01 Description

This section covers the supply and installation of special polymer flooring.

##### 1.02 Submittal

- A Copies of product data and color charts for colour selection.
- B Three sets of 300 x 300 x 50 mm concrete panels with samples of each material.
- C Test report from an approved testing laboratory attesting conformance with the minimum physical/chemical characteristics of material proposed.

##### 1.03 Manufacturer

Special flooring shall be the product of a firm which has been, and is now, engaged in manufacturing polymer floor systems for the past ten years.

##### 1.04 Delivery, Storage and Handling

Deliver materials to job site in manufacturer's unopened containers clearly marked with manufacturer's name, brand, size, thickness, grade, colour and design. Store materials as per manufacturer's recommendations.

#### Part 2 Products

##### 2.01 General

- A 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, may be considered acceptable subject to the engineer's approval.

##### B Materials

- 1 Stonclads GS system, or approved equal, with the following characteristics:

<u>Property</u>	<u>Test method</u>	<u>Typical results</u>
Compressive strength	ASTM C579	69 n/mm <sup>2</sup> after 7 days
Tensile strength	ASTM C307	12 n/mm <sup>2</sup>
Percent elongation	ASTM D790	0.15
Flexural strength	ASTM C580	27.5 n/ mm <sup>2</sup>
Flexural modulus of elasticity	ASTM D790	13,790 n/ mm <sup>2</sup>
Hardness (Shore.Durometer)	ASTM D2290	85 - 90
Bond strength	ACI committee 403 pp. 1139-1141	2.8 n/ mm <sup>2</sup> (100% concrete failure)
Indentation	Mil-d-3134	No indentation
Coefficient of friction	ASTM D2047	0.6
Flammability	ASTM D635	Self-extinguishing, extent of burning max. 6 mm

<u>Property</u>	<u>Test method</u>	<u>Typical results</u>
Coefficient of linear thermal Expansion	ASTM D-696	3.5 x 10-5 inch by inch per Per degree f.
Water absorption	ASTM C413	0.2%
Heat resistance Limitation		60°C (for continuous exposure) 93 °C (for intermittent spills)
Heat deflection	ASTM D648	43 °C
Cure rate (at 25oc)		Allow 6 hours for foot traffic, 18 hours for light traffic, 24 hours for normal operations.

2. Stonkote sealer:
  - a. Shall be of 100 percent solids.
  - b. Two component ambient-cure coating based on a modified aliphatic amine curing agent.
  - c. Diglycidyl ether of bisphenol A epoxy resin.
  - d. Physical/chemical characteristics:

<u>Property</u>	<u>Typical results</u>
Solids	100%
Solvent	None
Pot life	20 minutes
Min. Dry film thickness	3-5 mils/coat
Theoretical coverage at 3.0 mils dft	18.5 sqm/unit
Cure rate at 25 °C	4-5 hours for tack-free light traffic, 10-12 hours for light traffic, 24 hours for normal operations
Temperature limitation	60 °C – continuous exposure, 93 °C - intermittent exposure
Fire resistance for dry film	Self-extinguishing

## Part 3 Execution

### 3.01 Condition of Surfaces

The contractor shall examine substrate, 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 Preparation

- A. Clean substrate to remove deleterious substances which would impair the work.
- B. Fill cracks, holes and depressions in the substrate. Surface shall be smooth, level and at proper elevation and shall not vary more than 1:900 in any direction from level, plumb or slopes shown. Remove roughness and protrusions from concrete surfaces by grinding. Use compounds for filling complying with resilient flooring manufacturer's recommendations.
- C. Prime, seal cover substrate if it is of a kind or in a condition which the manufacturer of the resilient flooring recommends to be primed, sealed or covered. Use materials complying with manufacturer's recommendations.
- D. Test concrete floors to ensure that they are dry before installation of resilient flooring.

**3.03 Installation**

- A Install resilient flooring in accordance with the manufacturer's printed instruction and recommendations.
- B Chase edges of areas where the installed floor does not butt against a vertical surface. Chase shall be 18 mm channel, saw-cut to a straight line, and chiseled to 6 mm depth.
- C Where required an expansion or control joint shall be saw-cut after floor installation and filled with manufacturer's flexible epoxy or urethane caulk systems.

**End of Section 09700**

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## Section 09870

### Coating Systems for Ferrous Metals

#### Part 1 General

##### 1.01 Description

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.
9. 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 18°C and 32°C.
  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 7°C and 35°C when applying coatings other than water-thinned and epoxy.
- B. Water-thinned coatings shall be applied only when ambient temperature is between 10°C and 32°C.
- 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  $55 \pm 2$  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  $55 \pm 2$  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  $68 \pm 3$  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  $85 \pm 5$  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 15°C.
    - 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 5°C 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. Coatings 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 14 C 39	Stone (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

Danger bands are to be provided on specified pipelines and at valves and comprise danger symbol diagonal stripes on yellow background 150 mm wide.

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		
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

<u>Item</u>	<u>BS 4800</u>	<u>Color Description</u>
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>
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 10°C for water thinned coatings and 7°C 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 16°C 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**

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**

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.
  17. Co-ordinate the work with all related trades, so that all finish painting of concealed parts is completed before such work commences.
  18. Do not finish paint exposed parts until after completion of works.
  19. 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 10160

### Toilet and Shower Partitions

#### 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 toilet and shower partitions.

##### 1.02 Submittals

- A Manufacturer's specifications and installation instructions.
- B Detailed shop drawings showing plans, elevations, and details, including specified items and interface with other work.
- C Two samples of each item of hardware and two 300 mm square samples of a door corner.

#### Part 2 Products

##### 2.01 General

Toilet partitions, shower compartments, shower seats, and locker benches shall be POLY-MAR HD solid 25 mm thick plastic as manufactured by Santana Products Company, or an approved equal by Capitol Partitions, Inc., or by Columbia Partitions. Color shall be equal to Santana's "desert beige."

##### 2.02 Materials

Panels, doors, pilasters, screens, and benches shall be fabricated from polymer resins under high pressure forming a single-component section that is:

1. Waterproof.
2. Corrosion-proof.
3. Impact-resistant.
4. Nonabsorbent.
5. Has a self-lubricating Plastic-Glaze 280 surface that resists marking with pens, pencils, lipsticks, and other writing or marking implements.

##### 2.03 Partitions, Pilasters And Screens

Partitions shall be 25 mm thick, with edges machined to a radius of 6 mm and with sharp corners removed. Dimension shall be as shown on drawings. Pilasters shall have 75 mm high stainless steel shoes attached by theft-resistant stainless steel sex bolts.

##### 2.04 Hardware

- A Hinges, door latches, door strikes, and wall brackets shall be stainless steel, US32.
- B Fasteners, shoes, and curtain hooks shall be stainless steel.



- C Headrail and shower curtain extrusions shall be Alloy 6061-T6 anti-grip with mill finish.
- D Door pulls, doorstops, and bumper/hooks shall be Zamac, US26 finish.

### **2.05 Shower Compartments**

- A Receptors shall be precast 1-piece terrazzo 150 mm high, made of white cement with black and white marble chips.
- B Receptor shoulders shall be rabbeted to receive panels.
- C Brass drain shall be cast integrally and shall provide for a caulked lead connection, not less than 25 mm deep to a 50 mm pipe.
- D Removable steel strainer plate with US26 finish.

### **2.06 Benches**

- A Shower compartment and locker room benches shall be seamless solid plastic as specified for partitions.
- B Each 500 mm section of benches shall have a minimum load-bearing capacity of 136 kg.
- C Hardware and fittings shall be stainless steel, US26 finish.

## **Part 3 Execution**

### **3.01 Installation**

Install partitions, compartments, and benches in accordance with approved shop drawings and manufacturer's instructions.

### **3.02 Clean-Up**

Finished surfaces shall be cleaned using materials and methods recommended by the plastics manufacturer.

**End of Section 10160**

## Section 10210

### Louvres and Vents

#### Part 1 General

##### 1.01 Summary

This Section includes furnishing and installation of fixed metal wall louvres and motorized dampers.

##### 1.02 Definitions

Refer to AMCA Publication 501-85 for definitions of terms for metal louvres not otherwise defined in this section or referenced standards.

##### 1.03 System Performance Requirements

- A Design, engineer, fabricate, and install exterior metal wall louvres to withstand the effects of loads and stresses from wind and normal thermal movement, noise or metal fatigue caused by louvre blade rattle or flutter, without evidencing permanent deformation of louver components including blades, frames, and supports, or permanent damage to fasteners and anchors.
- B Wind load uniform pressure of 1.2 kN/sqm acting inwards or outwards.
- C Normal thermal movement is defined as that resulting from the maximum change (range) in ambient temperature. Base design calculations on actual surface temperatures of metals due to both solar heat gain and night time sky heat loss.
- D Air Performance, Water Penetration, and Air Leakage Ratings. Provide louvres complying with performance requirements indicated as demonstrated by testing manufacturers stock units of height and width indicated, according to AMCA 500.

##### 1.04 Submittals

- A Product data for each product indicated.
- B Shop drawings including:
  - 1. Plans, elevations, sections.
  - 2. Details showing profiles, angles, spacing of louvre blades.
  - 3. Unit dimensions related to wall openings and construction.
  - 4. Free areas for each size indicated.
  - 5. Profiles of frames at jambs, heads and sills.
  - 6. Structural computations.
  - 7. Material properties.
  - 8. Other information needed for structural analysis which has been prepared by, or under the supervision of a qualified professional engineer.
- C Samples for initial selection purposes in form of manufacturer's colour charts showing full range of colors available for those units with factory-applied colour finishes. Samples

for verification purposes of each type of metal finish required, prepared on 150 mm square metal samples of same thickness and alloy indicated for final unit of Work. Where finishes involve normal colour and texture variations, include sample sets showing full range of variations expected.

- D Product test reports evidencing compliance of units with performance requirements indicated.

### **1.05 Quality Assurance**

- A Obtain louvres from a single source where alike in one or more respects with regard to type, design and factory-applied color finish.
- B Qualify welding processes and welding operators in accordance with AWS D1.2 and AWS D1.3. Certify that each welder employed in unit of Work of this section has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification. Testing for recertification is Contractor's responsibility.
- C Comply with SMACNA "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

### **1.06 Project Conditions**

#### Field Measurements

1. Check actual louvre openings by accurate field measurements before fabrication.
2. Show recorded measurements on final shop drawings.
3. Coordinate fabrication schedule with construction progress to avoid delay of the Work.
4. Where field measurements cannot be made without delaying the Work, guarantee opening dimensions and proceed with fabrication of louvers and vents without field measurements.
5. Coordinate wall construction to ensure that actual opening dimensions correspond to guaranteed dimensions.

## **Part 2 Products**

### **2.01 Materials**

- A Aluminium sheet shall be ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer to produce required finish.
- B Aluminium extrusions shall be ASTM B 221, Alloy 6063-T5 or T-52.
- C Fasteners shall be same basic metal and alloy as fastened metal, unless otherwise indicated. Do not use metals which are corrosive or incompatible with materials joined. Use types, gages, and lengths to suit unit installation conditions. Use Phillips flat-head machine screws for exposed fasteners, unless otherwise indicated.
- D Anchors and inserts shall be of type, size, and material required for type of loading and installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.

## 2.02 Fabrication

- A Fabricate louvers and vents to comply with requirements indicated for design, dimensions, materials, joinery, and performance.
- B Preassemble louvers in shop to minimize field splicing and assembly and disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Include supports, anchorages, and accessories required for complete assembly.
- C Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
- D Fabricate frames, including integral sills, to fit in openings of size indicated with allowances made for fabrication and installation tolerances of louvers, adjoining construction, and perimeter sealant joints.
- E Provide vertical mullions of type and at spacings indicated but not further apart than recommended by manufacturer, or 1.8 m on centre, whichever is less. At horizontal joints between louver units provide horizontal mullions except where continuous vertical assemblies are indicated.
- F. Join frame members to one another and to fixed louver blades with fillet welds, concealed from view, unless otherwise indicated, or size of louver assembly makes bolted connections between frame members necessary.

## 2.03 Fixed Extruded Aluminium Wall Louvres

Horizontal drainable fixed blade louvers shall be of extruded aluminum frames and louver blades designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and of channels in jambs and mullions. They shall comply with the following requirements:

1. Louver depth: 150 mm, unless otherwise indicated.
2. Frame thickness: 3.2 mm, unless otherwise indicated.
3. Louver blade thickness: 3.2 mm, unless otherwise indicated.
4. Louver blade angle:  $37\frac{1}{2}$  degrees, unless otherwise indicated.
5. Determined by testing units 1.2 m wide by 1.2 m high per AMCA Standard 500 the louver free area shall be not less than 50 percent of total surface area; the static pressure loss not more than  $37.4 \text{ N/m}^2$  at an airflow of 5 m/s free area intake velocity; and water penetration not more than 0.015 kg/sqm of free area at an airflow of 6 m/s free area velocity when tested for 15 minutes.

## 2.04 Finishes, General

Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes. Finish louvers after assembly.

## 2.05 Aluminium Finishes

Finish designations prefixed by "AA" conform to the system established by the Aluminum Association for designating aluminum finishes. Class I color anodized finish shall be:

1. AA-M12C22A42/A44

2. Mechanical Finish: as fabricated, nonspecular.
3. Chemical Finish: etched, Medium Matte.
4. Anodic Coating: Class II Architectural, film thicker than 0.7 mil with integral color or electrolytically deposited color. Complying with AAMA 606.1 or AAMA 608.1.
5. Color: As selected by Owner from within standard industry colors and color density range.

## 2.06 Control Dampers

Provide automatic or hand operated control dampers and motorized dampers as required. Construction shall be:

1. Damper frame: minimum of 16 gauge galvanized steel.
2. Damper blades: minimum of 16 gauge galvanized steel, 150 mm wide.
3. Control shaft: minimum of 12 mm zinc-plated.
4. Parallel or opposed blade design as recommended by manufacturer.
5. Leakage not to exceed 3.6 m<sup>3</sup>/m<sup>2</sup> of damper area at a differential pressure of one kN/m<sup>2</sup>.
6. Seals: inflatable seal blade edging with flexible metal compression seal.
7. Bearings: molded synthetic.
8. Finish: mill galvanized.

## 2.07 Damper Motors

Size each damper motor with sufficient power to provide 2-position action as required:

1. Provide permanent split-capacitor or shaded pole type motors with gear trains completely oil-immersed and sealed.
2. Equip spring-return, single phase, motors, where indicated on the Drawings or in operational sequence, with integral spiral-spring mechanism.
3. Furnish entire spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
4. Equip motors for outdoor locations and for outside air intakes with "O ring" gaskets designed to make motors completely weatherproof.
5. Furnish non-spring return motors for dampers larger than 2.3 sqm and for valves larger than 60 mm breakaway torque rating of 34 Nm. Size spring-return motors for running torque rating of 17 Nm, and breakaway torque rating of 17 Nm.

## 2.08 Limit Switches

Control dampers shall be provided with limit switches to verify damper open position.

1. Operating force: 0.45 Nm.
2. Single pole, double throw (SPDT).
3. Enclosure: NEMA 4X.
4. Design: side rotary with adjustable plunger and cam-tracking.
5. Minimum operating temperature capability: -12°C to 121°C.

# Part 3 Execution

## 3.01 Preparation

Coordinate setting drawings, diagrams, templates, instructions and directions for installation of anchorages which are to be embedded in concrete or masonry construction. Coordinate delivery of such items to project site.

### **3.02 Installation**

- A Locate and place louvre units plumb, level, and in proper alignment with adjacent work. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- B Form closely fitted joints with exposed connections accurately located and secured. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- C Provide cathodic barrier between concrete and aluminium. Protect galvanized and nonferrous metal surfaces from corrosion or galvanic action by application of a heavy coating of bituminous paint on surfaces which will be in contact with concrete, masonry, or dissimilar metals.
- D Repair finishes damaged by cutting, welding, soldering, and grinding operations require for fitting and jointing. Restore finishes so there is no evidence of corrective work. Return items which cannot be refinished in field to shop. Make required alterations and refinish entire unit, or provide new units.
- E Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses where required to make louver joints weathertight. Comply with Section 07920, applied during installation of louver.

### **3.03 Adjusting and Protection**

Protect louvers from damage of any kind during construction period including use of temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at time of Substantial Completion. Repair or replace louvers damaged during installation and construction to the satisfaction of Engineer. Clean and touch-up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

### **3.04 Cleaning**

Periodically clean exposed surfaces of louvers which are not protected by temporary covering. Remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning. Before final inspection, clean exposed surfaces with water and with a mild soap or detergent not harmful to finishes. Rinse thoroughly and dry surface.

**End of Section 10210**

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## Section 10270

### Access Flooring

#### Part 1 General

##### 1.01 Description

Provide access (raised) flooring as shown on the drawings and as specified herein.

##### 1.02 Submittals

- A Shop drawings shall indicate panel layout, railings, steps, ramps and other components and shall detail components of:
  - 1. Assembly
  - 2. Bracing
  - 3. Anchoring methods
  - 4. Edge details
  - 5. Interface with other construction.
  - 6. Identify pedestal locations.
- B Samples of floor panels and support system components, finishes, trim and colours.
- C Construct a job mock-up including two panels and six pedestals.
- D Test reports from an independent laboratory verifying compliance with specified performance levels.
- E Underfloor support structure design certified by a licensed structural engineer.

#### Part 2 Products

##### 2.01 Manufacturers

- A Product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.
- B Access floor system shall be an approved equal to "Series 800 all Steel Access Floor System" as manufactured by Tate Access Floors, Inc.
- C System Components
  - 1. Floor panels shall consist of a steel top sheet welded to a formed steel bottom pan and painted inside and outside with an approved epoxy paint.
  - 2. Understructure system to be supplied shall be "Stringerless - Gravity Held Panels" with standard Tate pedestal compartments corresponding to the Series "800 all Steel Access Floor System", with the following system performance requirements:
    - a. each standard pedestal shall provide a 2300 kg axial load without permanent deformation.
    - b. panels shall be capable of supporting a concentrated load of 454 kg, placed on 645 sq mm area at any location on the panel with a maximum top surface deflection of 2 mm. Permanent set under this load shall not exceed 0.25 mm.



- c. Ultimate strength of the floor system shall provide a loading capacity of 950 kg without failure.
  - d. Local and overall surface deformation shall not exceed 1 mm when subjected to 75 mm dia x 46 mm wide hard plastic wheel at 136 kg on the caster for 10 cycles over the same path and 150 mm dia x 38 mm corde hard neoprene wheel at 181 kg on the wheel for 10,000 passes over the same path.
  - e. Panels and supporting understructure shall withstand without failure an impact load any where in the panel of 45.4 kg dropped from a height of 900 mm onto a 645 sqmm area.
3. Finish surface of floor panels with "Modular Panel Mate Carpet Tile" from Tate.
  4. Provide manufacturer's standard air flow panels, handrails, closure plates, plenum dividers, cove base, access holes and service outlets as required and indicated on the Drawings.
  5. Provide 10 sqm floor panels, 1.5 sqm of understructure system and 2 panel lifting devices as spares.

## **Part 3 Execution**

### **3.01 Environmental Conditions**

- A During the installation of the access flooring system, the room temperature shall be not less than 15°C. Begin installation after the completion of other work which requires wet-applied materials and remove debris and dust. Ensure that new concrete is dry.
- B Coatings, such as sealer, hardener, paint, or other materials which would prevent proper adhesion, shall be removed by grinding or scraping before applying adhesive. Test for adhesion by applying dabs of adhesive to various locations in the area to receive pedestals and leave approximately 24 hours. If the adhesive peels off easily, allow the new floor to continue to dry and again work the coated floors.
- C Coordinate installation with other trades for under-floor smoke detection, under-floor fire extinguishing systems, wiring, conduit, etc.

### **3.02 Installation**

Install the floor system and accessories according to manufacturer's recommendations to ensure a rigid, firm installation, free of vibration, rocking, and other unacceptable performance. Provide additional pedestals where grid is disrupted by columns, walls, and cutouts that impair strength of system. Verify that panels are interchangeable and fit snugly but do not bind when placed in alternate positions. Provide positive continuing electrical grounding of entire floor assembly. Accurately scribe and fit plenum fascia to subfloor.

### **3.03 Cleaning, Protection, and Final Adjustments**

After completion of the installation, vacuum clean the entire system. Protect area with 9 kg kraft paper sealed to prevent tearing until acceptance of the building by the Employer. Before equipment is moved across the floor, the floor shall be protected by 12 mm plywood.

**End of Section 10270**

## Section 10400

### Identifying Devices

#### Part 1 General

##### 1.01 Description

Provide identifying devices as indicated on the drawings and specified herein.

##### 1.02 Submittals

A Shop drawings shall indicate:

1. Size
2. Mounting
3. Letterstyle
4. Size
5. Spacing
6. Colours

B One sample sign for each approved sign category with manufacturer's available colours and lettering styles.

#### Part 2 Products

##### 2.01 Manufacturers

The product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.

##### 2.02 Interior/Exterior Signs

Identifying devices shall be of the type and material as shown on the drawing. For purposes of establishing a standard of quality those of the Seton Name Plate Corporation may be used. All lettering shall be in English and the local language to the approval of the Employer.

##### 2.03 Building Identification Signs

Building identification signs shall be as shown on the Drawings.

#### Part 3 Execution

##### 3.01 Installation

Install all signage in accordance with the manufacturer's recommendations and approved shop drawings.

**End of Section 10400**

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## Section 10520

### Fire Protection Specialties

#### Part 1 General

##### 1.01 Description

Furnish all labor, materials, equipment and appurtenances required to install fire extinguishers as specified herein or as shown on the Drawings.

##### 1.02 Submittals

- A Manufacturer's literature, or catalog cuts to Engineer for approval
- B Shop drawings showing schedule of fire extinguishers required for each building indicating installation details for specified fire extinguishers.

##### 1.03 Quality Assurance

Provide portable fire extinguishers and accessories by a single company. Portable fire extinguishers shall be U.L. listed and shall bear U.L. "Listing Mark" for type, rating, and classification of extinguishers indicated.

#### Part 2 Products

##### 2.01 General

Portable fire extinguishers shall be ABC Dry powder Fire Extinguishers

##### 2.02 Manufacturers

- A The product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.
- B Fire extinguishers shall be as manufactured by Larsons' Manufacturing Company, J.L. Industries, Potter-Roomer or approved equal.
- C All fire extinguishers shall be furnished complete with a 6-year annual inspection and a service maintenance contract six years after acceptance by the Owner.

#### Part 3 Execution

##### 3.01 Installation

- A Install fire extinguishers units in locations indicated, or as directed by the Engineer or the Employer, at heights to comply with applicable regulations of governing authorities.
- B Securely fasten mounting brackets to structure or substrate, square and plumb, to comply with manufacturer's instructions.
- C Check extinguishers for proper charge and operation.

- D Remove and replace damaged, defective or undercharged units.

**End of Section 10520**

## **Section 10670**

### **Storage Equipment**

#### **Part 1 General**

##### **1.01 Description**

Provide miscellaneous storage equipment and accessories as indicated on the drawings and as specified herein.

##### **1.02 Submittals**

Provide product specification data on all storage equipment specified herein.

#### **Part 2 Products**

##### **2.01 Manufacturers**

- A The product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.
- B For the purposes of establishing a minimum standard of quality and workmanship, the products of Lyon Metal Products, Inc. (LMPI).
- C Equipment numbers indicated on drawings are keyed to corresponding equipment numbers.

#### **Part 3 Execution**

##### **3.01 Installation**

Shelvings, racks, benches and related accessories shall be assembled and installed at locations shown on the drawings, in accordance with the manufacturers' recommendations. Assemblies shall be level, rigid and plumb.

**End of Section 10670**

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## Section 10800

### Sanitary Fittings and Toilet Accessories

#### Part 1 General

##### 1.01 Description

Provide sanitary fittings and toilet accessories as indicated on the drawings and specified herein.

##### 1.02 Submittals

- A Manufacturer's technical data and installation instructions for each sanitary fitting and toilet accessory. Provide samples for approval.
- B Provide shop drawings, templates, instructions and directions for installation of anchorage devices in other work.

##### 1.03 Quality Assurance

- A Provide products of the same manufacture for each type of fitting and accessory unit and for units exposed in the same areas.
- B Product and manufacturer specified hereinafter are specified for the purpose of establishing minimum quality standards. Products equal in quality to, or better than, those specified may be acceptable subject to the Engineer's approval.
- C Provide locks where indicated, with the same keying for each type of accessory unit in the project wherever possible. Furnish 2 keys for each lock.

#### Part 2 Products

##### 2.01 Sanitary Fittings

- A All sanitary fittings, washbasins, urinals, WC suites, squatting pans etc. shall be of the best quality and shall be obtained from a manufacturer to the approval of the Engineer and supplied complete with all flush pipes, taps, valves, siphons, brackets, waste plugs and chains, etc. of approved patterns. The quality of all ceramic sanitary fittings shall comply with BS 3402.
- B WC suites shall be to an approved colour and shall be of vitreous china complying with BS 5503 with "P" or "S" trap, as required. They shall include a low level vitreous china cistern to BS 1125 close mounted to the pan and incorporating a siphonic flushing system with 12 mm low pressure ball valve complying with BS 1212. WC suites shall be provided with plastic seat and cover complying with BS 1254.
- C Each WC suite shall have a porcelain toilet paper holder fixed within the wall and adjacent to it.
- D Each squatting pan set shall be of vitreous china complying with BS 5503 with "P" or "S" trap, as required, and shall include a high level cistern of vitreous china, complete



with siphonic flushing system with 12 mm low pressure ball valve complying with BS 1212.

- E The inlet to each cistern shall be fitted with a 12 mm stop valve complying with BS 1010.
- F Wash basins shall be of vitreous china complying with BS 1188. Wash basins shall be supplied with chromium plated drains complete with rubber stopper and chromed metallic chain. Each basin shall be fitted with a 30 mm diameter detachable siphon trap (bottle trap) which shall be connected to the nearest floor drain, gully trap or drainage pipe by a 50 mm diameter galvanized pipe. Each basin shall be fitted complete with chromium plated tap for cold water. Each wash basin shall be supplied with vitreous china soap tray, towel rack with chromium plated bar and clothes hanger of quality and make approved by the Engineer. Colours shall be approved by the Engineer.
- G Sinks shall be shall be of vitreous china size 600 mm x 450 mm x 250 mm deep, shall conform to BS 1188 and shall have an overflow in centre back. Metal sinks shall be stainless steel to the sizes specified and shall conform to BS 1244:Part 2 Type A. Each sink shall be provided with a 40 mm chromium plated brass waste outlet with grating. A 40 mm trap shall be fitted to each sink, having a 40 mm or 75 mm deep seal as necessary. One or two 12 mm bib taps, as required shall be fixed with extension pieces of adequate length.
- H All taps, mixers, stop valves and the like shall be chromium plated with metal handles and comply to BS 5412. Basins and sinks shall be completed with 12 mm diameter cross head taps. Bib taps, unless otherwise stated shall be 12 mm diameter chromium plated brass with cross heads, complete with backplate elbow or wall flange. Bib taps to stand pipes shall be 12 mm diameter unplated brass, and shall have an extended nozzle for hose connection. Manual mixing valves shall comply with BS 1415:Part 1. All taps shall be colour coded hot and cold.
- I Shower fittings shall comprise an adjustable chromium plated brass inclined shower head with 12 mm supply pipe(s).
- J Other items shall conform to the requirements of Section 15410.

## **2.02 Delivery, Storage and Handling**

- A. Deliver sanitary fittings and toilet accessories to project site in manufacturer's unopened containers, fully identified.
- B. Store in accordance with manufacturer's recommendations and protect from weather, staining, damage and loss.

## **Part 3 Execution**

### **3.01 Installation**

- A The installation shall be carried out in accordance to the satisfaction of, and in accordance with all local regulations and by-laws and Section 15410.
- B Installation shall generally comply with BS 6465:Part 1, BS 6700 and BS 5572.
- C All sanitary fittings shall be set level and true and shall drain away completely on emptying. They shall be fixed securely to floors and walls as appropriate and all

protective paper shall be removed from concealed edges before fixing. All fittings shall be tested and adjusted to the satisfaction of the Engineer on completion.

- D Concealed fastenings shall be used wherever possible.
- E Provide anchors, bolts, and other necessary anchorages, and attach accessories securely to walls and partitions in locations as shown or directed.
- F Install concealed mounting devices and fasteners fabricated of the same material as the accessories, or of galvanized steel, as recommended by manufacturer.
- G Install exposed mounting devices and fasteners finished to match the fittings or accessories.
- H Provide theft-resistant fasteners for mountings.
- I Secure sanitary fittings and toilet room accessories in accordance with the manufacturer's instructions for each item and each type of substrate construction.

**End of Section 10800**

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