

REPUBLIC OF LEBANON

Council for Development and Reconstruction

Completion of Construction and Operation of Ghadir Marine Landfill

Tender Documents

Volume 2
Technical Specifications

April 2023



Rafik El-Khoury & Partners
Consulting Engineers SAL



TABLE OF CONTENTS

DIVISION 1 - GENERAL REQUIREMENTS

CDR GENERAL REQUIREMENTS

DIVISION 2 - SITE CONSTRUCTION

SECTION 02620 - SUBDRAINAGE

SECTION 02721 - AGGREGATE SUB-BASE AND BASE COURSES

SECTION 02740 - FLEXIBLE PAVEMENT

SECTION 02631 - STORMWATER DRAINAGE SYSTEMS

SECTION 02811 - LANDSCAPE IRRIGATION

SECTION 02820 - FENCES AND GATES

SECTION 02923 - LANDSCAPE GRADING

SECTION 02930 - EXTERIOR PLANTS

DIVISION 3 - CONCRETE

SECTION 03100 - CONCRETE FORMS AND ACCESSORIES

SECTION 03200 - CONCRETE REINFORCEMENT

SECTION 03300 - CAST-IN-PLACE CONCRETE

SECTION 03455 - PLANT-PRECAST CONCRETE

DIVISION 5 - METALS

SECTION 05120 - STRUCTURAL STEEL

SECTION 05500 - METAL FABRICATION

DIVISION 7 - THERMAL AND MOISTURE PROTECTION

SECTION 07130 - SHEET WATERPROOFING

SECTION 07140 - FLUID-APPLIED WATERPROOFING

SECTION 07212 - BOARD INSULATION

SECTION 07260 - VAPOR RETARDERS

SECTION 07270 - AIR BARRIERS

SECTION 07613 - MANUFACTURED SHEET METAL ROOFING

SECTION 07620 - SHEET METAL FLASHING AND TRIM

SECTION 07900 - JOINT SEALERS

DIVISION 9 - FINISHES

SECTION 09220 - PORTLAND CEMENT PLASTER

SECTION 09626 - SAND CEMENT SCREED FLOORING

SECTION 09900 - PAINTS AND COATINGS

ANNEXES

ANNEX 1 - LANDFILL LEACHATE MANAGEMENT SYSTEMS

ANNEX 2 - LANDFILL GAS TECHNICAL SPECIFICATIONS

ANNEX 3 - LEGAL FRAMEWORK

ANNEX 4 - DESIGN REQUIREMENTS FOR SANITARY LANDFILLS

ANNEX 5 - ENVIRONMENTAL GUIDELINES FOR OPERATION OF SANITARY LANDFILLS

General Requirements

- 1- Description of Works and Site**
- 2- Documents and Drawings**
- 3- Management Procedures**
- 4- Quality Standards and Control**
- 5- Temporary Works and Services**

November 2022

Rev 1.3

Table of Contents

Clause No.	Page No.
1- DESCRIPTION OF WORK AND SITE.....	1
1-1 THE WORKS.....	1
1-1-1 General Description.....	1
1-1-2 The Works.....	2
1-1-3 Concurrent Work	3
1-1-4 Restraints.....	3
1-1-5 Phasing Of Work	3
1-1-6 Sectional Completion	3
1-1-7 Restrictions on Methods of Working.....	3
1-1-8 Sequence of Construction	3
1-1-9 Restrictions on Times of Working	4
1-2 THE SITE.....	4
1-2-1 General	4
1-2-2 Contractors Site Compound.....	4
1-2-3 Existing Utilities and Obstacles.....	4
1-2-4 Utility Diversions.....	5
2- DOCUMENTS AND DRAWINGS	5
2-1 DOCUMENTS GENERALLY	5
2-2 DRAWINGS.....	5
2-2-1 Contract Drawings.....	5
2-2-2 Dimensions and Details.....	6
2-3 DRAWINGS ETC. PROVIDED BY THE CONTRACTOR.....	6
2-3-1 General	6
2-3-2 Design	6
2-3-3 Design and Shop Drawings.....	6
2-3-4 Supporting Data	6
2-3-5 Procedure for Submission and Approval	6
2-3-6 "As-Built" Drawings.....	7
2-3-7 Instruction and Maintenance Manuals.....	7
2-3-8 Completion.....	7
2-4 BILL OF QUANTITIES.....	8
2-4-1 Measurement Procedures Generally.....	8
2-4-2 Field Measurements	8
2-4-3 Manufactured Items.....	8
2-4-4 Gage Designations.....	8
2-4-5 Fittings and Accessories.....	8
2-4-6 Weight Measurements	8
2-4-7 Linear and Area Measurements	9
2-4-8 Volume Measurements in Vehicles	9
2-4-9 Earthwork Volume Measurements.....	9
2-4-10 Ordering Materials	10
2-4-11 Shop Drawings.....	10
2-5 PROCEDURE NOTE 1.....	11
2-5-1 Submittals For Shop Drawings.....	11
2-5-1-1 Shop Drawings.....	11
2-6 PROCEDURE NOTE 2.....	11
2-6-1 Submittals For Product Data	11
2-6-1-1 Product Data.....	11
2-7 PROCEDURE NOTE 3.....	12

2-7-1	<i>Instruction And Maintenance Manuals</i>	12
2-7-1-1	<i>Summary</i>	12
2-7-1-2	<i>Quality Assurance</i>	12
2-7-1-3	<i>Submittals</i>	13
2-7-1-4	<i>Manual Content</i>	14
2-7-1-5	<i>Material And Finishes Maintenance Manual</i>	15
2-7-1-6	<i>Equipment And Systems Maintenance Manual</i>	16
2-7-1-7	<i>Instructions Of The Employer's Personnel</i>	17
3-	MANAGEMENT PROCEDURES	18
3-1	COMMENCEMENT, PROGRAM AND PROGRESS.....	18
3-1-1	<i>Commencement</i>	18
3-1-2	<i>Co-Ordination</i>	18
3-1-3	<i>Program</i>	18
3-1-4	<i>Guidance</i>	19
3-1-5	<i>Hardware</i>	19
3-1-6	<i>Computer Software</i>	19
3-1-7	<i>Resource Schedules</i>	19
3-1-8	<i>Cash Flow Estimate</i>	19
3-1-9	<i>Monitoring</i>	19
3-1-10	<i>Computer Program</i>	20
3-1-11	<i>Materials Procurement Schedules</i>	20
3-2	RECORDS AND MEASUREMENTS.....	20
3-2-1	<i>Labor Record</i>	20
3-2-2	<i>Materials And Plant Record</i>	20
3-2-3	<i>Equipment Record</i>	20
3-2-4	<i>Daily Work Record</i>	20
3-2-5	<i>Monthly Report</i>	20
3-2-6	<i>Wages Books And Time Sheets</i>	21
3-2-7	<i>Climatic Conditions</i>	21
3-2-8	<i>Special Records</i>	21
3-2-9	<i>Photographs</i>	21
3-3	SITE ADMINISTRATION.....	21
3-3-1	<i>Engineer's Site Meetings</i>	21
3-3-2	<i>Contractor's Site Meetings</i>	21
3-3-3	<i>Co-Ordination Of Subcontractors Etc</i>	21
3-3-4	<i>Quality Control</i>	22
3-3-5	<i>Procedures Manual</i>	22
3-4	COMPLETION.....	22
3-4-1	<i>Notice Of Completion</i>	22
3-4-2	<i>Making Good Defects</i>	22
4-	QUALITY STANDARDS AND CONTROL	23
4-1	GENERALLY.....	23
4-1-1	<i>Good Practice</i>	23
4-2	SETTING OUT AND ACCURACY.....	23
4-2-1	<i>Site Survey</i>	23
4-2-2	<i>General Setting Out</i>	23
4-2-3	<i>Setting Out Utility Works</i>	23
4-2-4	<i>Setting Out Civil Work</i>	23
4-2-5	<i>Record Drawings</i>	23
4-2-6	<i>All Dimensions And Levels</i>	24
4-2-7	<i>Appearance And Fit</i>	24
4-2-8	<i>Non-Compliance</i>	24
4-3	MATERIALS.....	24
4-3-1	<i>Products</i>	24
4-3-2	<i>Product List Schedule</i>	24

4-3-3 Standards...	24
4-3-4 Single Sources...	24
4-3-5 Checking Compliance Of Products And Materials...	25
4-3-6 Storage Of Materials...	25
4-3-7 Protection Of Products And Materials ...	25
4-3-8 Materials Supplied By Employer...	26
4-3-9 Local Material Sources ...	26
4-4 CONTRACTOR'S PLANT AND EQUIPMENT ...	26
4-4-1 Plant And Equipment.....	26
4-4-2 Plant And Equipment Of A Particular Size or Type ...	26
4-4-3 Contractor's Schedule Of Plant And Equipment ...	26
4-4-4 Provision And Use Of Plant And Equipment ...	26
4-4-5 Removal From Site.....	27
4-5 WORKMANSHIP ...	27
4-5-1 Work	27
4-5-2 Manufacturer's Recommendations.....	27
4-5-3 Suitability Of Previous Work And Conditions.....	27
4-5-4 Defects In Existing Work.....	27
4-5-5 Rectification Of Defective Work ...	27
4-5-6 Warranties.....	27
4-5-7 Warranties Employer Recourse.....	28
4-6 SAMPLES AND APPROVALS.....	28
4-6-1 Samples.....	28
4-6-2 Source Tests	29
4-6-3 Approvals ...	29
4-7 WORK AT COMPLETION.....	29
4-7-1 Clearing Etc.....	29
4-7-2 Temporary Markings.....	30
4-7-3 Partial Possession By Employer ...	30
4-7-4 Project Completion Procedures.....	30
4-8 PROCEDURE NOTE 4.....	30
4-8-1 Product Selection ...	30
4-8-1-1 Product Selection.....	30
4-9 PROCEDURE NOTE 5.....	31
4-9-1 Submittal Of Samples ...	31
4-9-1-1 Samples.....	31
4-10 PROCEDURE NOTE 6.....	32
4-10-1 Part 1 - Final Cleaning.....	32
4-10-1-1 Final Cleaning.....	32
4-10-2 Part 2-Products.....	33
4-10-2-1 Materials.....	33
4-10-3 Part 3 - Execution.....	33
4-10-3-1 Final Cleaning (where applicable).....	33
4-11 PROCEDURE NOTE 7.....	34
4-11-1 Part 1 - Project Completion.....	34
4-11-1-1 Summary.....	34
4-11-1-2 Partial Completion.....	34
4-11-1-3 Final Completion.....	34
4-11-1-4 Record Document Submittals ...	35
4-11-2 Part 2 - Execution.....	36
4-11-2-1 Close-Out Procedures (where applicable).....	36
5-1 GENERALLY.....	37
5-1-1 Locations.....	37
5-1-2 Standards And Details.....	37
5-1-3 Temporary Works.....	37
5-1-4 General	37
5-2 TEMPORARY SITE FACILITIES.....	37
5-2-1 Roads.....	37

5-2-2 Diversions...	38
5-2-3 Trench Crossings.....	38
5-2-4 Temporary Site Fence	38
5-2-5 Nameboard.....	38
5-3 CONTRACTOR'S TEMPORARY OFFICES.....	38
5-3-1 Contractor's Temporary Offices.....	38
5-3-2 Temporary Laboratory.....	39
5-4 TEMPORARY SERVICES.....	39
5-4-1 Water.....	39
5-4-2 Electricity.....	39
5-4-3 Power	39
5-4-4 Lighting	39
5-4-5 Permanent Electric Supply And Lighting Installation.....	39
5-5 TEMPORARY FACILITIES FOR THE ENGINEER AND/OR EMPLOYER.....	39
5-5-1 General	39
5-5-2 Representative's Site Offices.....	40
5-5-2-1 Furniture And Equipment.....	40
5-5-2-2 Conference Room Furniture And Equipment.....	40
5-5-2-3 Kitchen Furniture And Equipment.....	41
5-5-2-4 Store Room Furniture And Equipment.....	41
5-5-2-5 Lavatory Furniture And Equipment	41
5-5-2-6 Services	41
5-5-2-7 Telephones.....	42
5-5-2-8 Car Ports.....	42
5-5-3 Representative's Vehicles.....	42
5-5-4 Vehicle Driver.....	42
5-5-5 Computer.....	42
5-5-6 Surveying Equipment And Assistance.....	42
5-5-7 Thermometers.....	43
5-5-8 Test Equipment.....	43
5-5-9 Inspection Facilities.....	43
5-5-10 Digital Camera.....	43
5-6 DIVERSION OF PUBLIC UTILITY SERVICES.....	43
5-6-1 Temporary Diversion Of Existing Public Utility Services.....	43
5-6-2 Permanent Diversion Of Existing Public Utility Services.....	43

1- DESCRIPTION OF WORK AND SITE

1-1 The Works

1-1-1 General Description

Sanitary Landfill will be situated at an altitude ranging between +6 M above mean sea level (m.s.l.) and approx. +16M (top of final cap) above sea level (a.s.l.) in the Mohafaza of Mount Lebanon in Aalay Caza at the following stereographic coordinates:

X -339830 m and Y – 36747 m

The Sanitary Maritime Landfill will be located in the Reclaimed Land opposite Costa Brava Area.

The Sanitary Maritime Landfill will extend over a surface area of approximately 78480 m².

The Completion of Construction and Operation of the Sanitary Maritime Landfill is planned to have a capacity of approximately 370,000 tons of baled municipal solid waste or loose Municipal Solid Waste to be landfilled in sanitary cell 1 extension and capping of Cell 2 extension and Completion and Operation & Maintenance of Leachate Treatment and Gas collection and Flaring.

1-1-2 The Works

The extent of the works includes but without limitation, the following main elements:

A. Construction:

1. Topographic survey of the area of the project
2. Site preparatory works between Cell 1 and phase 1
3. Soil Backfill in Ghadir W.W.T.P reserved area up to +2 m level.
4. preparation of the lining and drainage layers for cell 1 extension, daily landfilling operations related to intermediate soil covers, and the final capping of sanitary cell 1 extension.
5. Final capping of sanitary cell 2 extension.
6. Design and installation of Leachate Collection, including all necessary leachate collection pipes, collection sumps or tanks and pumping sets controls and monitoring devices, accessories, connections, testing and commissioning and other related works to connect to the existing Leachate Collection System.
7. Design and installation of Landfill Gas Collection System, including all necessary vertical wells, pumping units, controls and monitoring devices, accessories, connections, testing and commissioning and other related works with connection to existing System.
8. Construction Works of Ancillary Buildings and Siteworks

B. Operation:

1. Receipt of MSW from Collection Contractors principally Aalay, Baabda and Chouf.
2. MSW landfilling activities including the stacking of MSW bales and/or placement of waste bulk in layers in Landfill Cells and placement of daily intermediate covers.
3. Final Cap and Landfill Closure in both cell 1 and cell 2.
4. Operating of leachate collection and treatment system and Operating of Gas collection & flaring System.
5. General Management of all landfill operations (of administrative and technical aspects).

1-1-3 Concurrent Work

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

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

1-1-4 Restraints

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

1-1-5 Phasing Of Work

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

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

1-1-6 Sectional Completion

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

1-1-7 Restrictions on Methods of Working

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

1-1-8 Sequence of Construction

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

1-1-9 Restrictions on Times of Working

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

1-2 The Site

1-2-1 General

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

1-2-2 Contractors Site Compound

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

1-2-3 Existing Utilities and Obstacles

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

The Contractor shall :

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

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

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

1-2-4 Utility Diversions

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

2- DOCUMENTS AND DRAWINGS

2-1 Documents Generally

The Documents are arranged in four volumes namely :

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

2-2 Drawings

2-2-1 Contract Drawings

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

2-2-2 Dimensions and Details

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

2-3 Drawings Etc. Provided by the Contractor 2-3-

1 General

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

2-3-2 Design

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

2-3-3 Design and Shop Drawings

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

2-3-4 Supporting Data

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

2-3-5 Procedure for Submission and Approval

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

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

2-3-6 “As-Built” Drawings

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

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

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

2-3-7 Instruction and Maintenance Manuals

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

2-3-8 Completion

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

2-4 Bill Of Quantities

2-4-1 Measurement Procedures Generally

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

2-4-2 Field Measurements

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

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

2-4-3 Manufactured Items

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

2-4-4 Gage Designations

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

2-4-5 Fittings and Accessories

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

2-4-6 Weight Measurements

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

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

2-4-7 Linear and Area Measurements

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

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

2-4-8 Volume Measurements in Vehicles

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

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

2-4-9 Earthwork Volume Measurements

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

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

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

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

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

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

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

2-4-10 Ordering Materials

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

2-4-11 Shop Drawings

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

2-5 Procedure Note 1

2-5-1 Submittals For Shop Drawings

2-5-1-1 Shop Drawings

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

2-6 Procedure Note 2

2-6-1 Submittals For Product Data

2-6-1-1 Product Data

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

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

2-7 Procedure Note 3

2-7-1 Instruction And Maintenance Manuals 2-7-

1-1 Summary

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

2-7-1-2 Quality Assurance

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

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

2-7-1-3 Submittals

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

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

2-7-1-4 Manual Content

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

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

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

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

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

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

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

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

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

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

3- MANAGEMENT PROCEDURES

3-1 Commencement, Program And Progress 3-1-

1 Commencement

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

3-1-2 Co-Ordination

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

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

3-1-3 Program

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

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

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

3-1-4 Guidance

The Contractor shall abide by the following :

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

3-1-5 Hardware

The computer hardware shall be IBM compatible

3-1-6 Computer Software

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

3-1-7 Resource Schedules

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

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

3-1-8 Cash Flow Estimate

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

3-1-9 Monitoring

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

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

3-1-10 Computer Program

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

3-1-11 Materials Procurement Schedules

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

3-2 Records And Measurements

3-2-1 Labor Record

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

3-2-2 Materials And Plant Record

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

3-2-3 Equipment Record

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

3-2-4 Daily Work Record

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

3-2-5 Monthly Report

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

3-2-6 Wages Books And Time Sheets

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

3-2-7 Climatic Conditions

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

Air temperatures: maximum and minimum

Humidity

Rainfall : total in mm and hours

3-2-8 Special Records

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

3-2-9 Photographs

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

3-3 Site Administration

3-3-1 Engineer's Site Meetings

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

3-3-2 Contractor's Site Meetings

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

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

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

3-3-4 Quality Control

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

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

3-3-5 Procedures Manual

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

3-4 Completion

3-4-1 Notice Of Completion

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

3-4-2 Making Good Defects

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

4- QUALITY STANDARDS AND CONTROL 4-1

Generally

4-1-1 Good Practice

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

4-2 Setting Out And Accuracy

4-2-1 Site Survey

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

4-2-2 General Setting Out

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

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

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

4-2-3 Setting Out Utility Works

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

4-2-4 Setting Out Civil Work

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

4-2-5 Record Drawings

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

4-2-6 All Dimensions And Levels

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

4-2-7 Appearance And Fit

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

4-2-8 Non-Compliance

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

4-3 Materials

4-3-1 Products

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

4-3-2 Product List Schedule

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

4-3-3 Standards

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

4-3-4 Single Sources

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

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

4-3-5 Checking Compliance Of Products And Materials

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

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

4-3-6 Storage Of Materials

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

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

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

4-3-7 Protection Of Products And Materials

The Contractor shall:

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

4-3-8 Materials Supplied By Employer

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

4-3-9 Local Material Sources

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

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

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

4-4 Contractor's Plant And Equipment

4-4-1 Plant And Equipment

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

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

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

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

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

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

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

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

4-4-5 Removal From Site

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

4-5 Workmanship

4-5-1 Work

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

4-5-2 Manufacturer's Recommendations

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

4-5-3 Suitability Of Previous Work And Conditions

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

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

4-5-4 Defects In Existing Work

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

4-5-5 Rectification Of Defective Work

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

4-5-6 Warranties

The Contractor shall:

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

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

4-5-7 Warranties Employer Recourse

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

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

4-6 Samples And Approvals

4-6-1 Samples

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

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

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

4-6-2 Source Tests

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

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

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

4-6-3 Approvals

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

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

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

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

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

4-7 Work At Completion

4-7-1 Clearing Etc.

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

4-7-2 Temporary Markings

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

4-7-3 Partial Possession By Employer

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

4-7-4 Project Completion Procedures

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

4-8 Procedure Note 4

4-8-1 Product Selection

4-8-1-1 Product Selection

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

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

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

4-9 Procedure Note 5

4-9-1 Submittal Of Samples

4-9-1-1 Samples

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

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

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

4-10 Procedure Note 6

4-10-1 Part 1 - Final Cleaning

4-10-1-1 Final Cleaning

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

4-10-2 Part 2-Products

4-10-2-1 Materials

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

4-10-3 Part 3 - Execution

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

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

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

4-11 Procedure Note 7

4-11-1 Part 1 - Project Completion

4-11-1-1 Summary

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

4-11-1-2 Partial Completion

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

4-11-1-3 Final Completion

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

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

4-11-1-4 Record Document Submittals

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

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

4-11-2 Part 2 - Execution

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

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

5- TEMPORARY WORKS AND SERVICES

5-1 Generally

5-1-1 Locations

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

5-1-2 Standards And Details

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

5-1-3 Temporary Works

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

5-1-4 General

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

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

5-2 Temporary Site Facilities

5-2-1 Roads

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

5-2-2 Diversions

The Contractor shall:

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

5-2-3 Trench Crossings

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

5-2-4 Temporary Site Fence

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

5-2-5 Nameboard

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

5-3 Contractor's Temporary Offices

5-3-1 Contractor's Temporary Offices

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

5-3-2 Temporary Laboratory

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

5-4 Temporary Services

5-4-1 Water

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

5-4-2 Electricity

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

5-4-3 Power

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

5-4-4 Lighting

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

5-4-5 Permanent Electric Supply And Lighting Installation

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

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

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

5-5-1 General

All facilities provided for the Engineer's and/or Employer's staff shall remain available until the end of the defects liability period or until such earlier time as the Engineer may instruct.

5-5-2 Representative's Site Offices

The Contractor shall provide prefabricated portable or demountable offices or other as may be approved by the Engineer, for the sole use of the Engineer's Representative and his staff, comprising:

- 2 offices size of each approximately 4m x 5m
- Meeting room for 12 people
- Secretary's room of approximately size 4m x 5m
- 1 Kitchenette.
- 2 Toilets.
- **1 Store room.**
- Car shades for 4 cars.

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

5-5-2-1 Furniture and Equipment

Each office shall contain:

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

And, in addition, the following shall be provided for the Secretary's Office:

- Secretary's desk and swivel chair
- 2 large lockable sheet filing cabinets
- 2 reference tables
- 6 office chairs
- 10 calculators
- 1 photocopying machine with duplex, sorter and document feeder + consumables + all photocopying papers.
- Pinboards, shelves and waste paper baskets.
- All consumables and all stationery and office supplies.

5-5-2-2 Conference Room Furniture and Equipment

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

- 1 Conference table for 12 people
- 12 chairs
- 2 shelves

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

5-5-2-3 Kitchen Furniture and Equipment

Shall comprise for each pantry:

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

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

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

Shall comprise:

- Shelve units
- Drawing hangers and racks.

5-5-2-5 Lavatory Furniture and Equipment

Shall comprise for each lavatory:

- 1 European wc suite
- 1 toilet roll holder
- 1 wash hand basin with shelf
- 1 mirror
- 1 paper towel holder
- 1 soap dispenser
- 1 waste basket with cover
- 1 extractor fan

And all necessary consumables

5-5-2-6 Services

The contractor shall provide and maintain the following minimum services:

- Heating and air – conditioning for each room office
- Electric lighting and power
- Water supply
- Drainage system
- Fire fighting appliances
- Cleaning facilities and general attendance

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

5-5-2-7 Telephones

The contractor shall provide a **four** separate telephone connections, **two** which **are** mobile and two fixed for office use and facsimile. The contractor shall pay all installation, rental and call charges.

5-5-2-8 Car Ports

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

5-5-3 Representative's Vehicles

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

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

5-5-4 Vehicle Driver

Not Applicable

5-5-5 Computer

The contractor shall provide on site for the use of the Engineer's Representative and his staff **three** latest model computers along with the necessary operating systems, softwares, A4 laser printer, A3 plotter and UPS, **with all consumables and all stationery and office supplies.**

5-5-6 Surveying Equipment and Assistance

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

5-5-7 Thermometers

The following shall be provided on site:

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

5-5-8 Test Equipment

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

5-5-9 Inspection Facilities

The contractor shall provide all ladders, access lighting facilities and assistance etc. required by the project manager representative / Engineer's Representative to inspect any part of the works.

5-5-10 Digital Camera

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

5-6 Diversion of Public Utility Services

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

Where execution of the works involves the temporary diversion of existing public utility services, the contractor shall perform such temporary diversion and shall maintain the follow or service as directed by the engineer. Unless otherwise stated the cost will be deemed to be included in the contractor price.

5-6-2 Permanent Diversion of existing Public Utility Services

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



SECTION 02620

SUBDRAINAGE

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Drainage system of building perimeter, retaining wall, slab-on-grade, base slabs and raft foundations.
 - 2. Filter aggregate, drainage pipes and filter fabric.
- B. Related Sections:
 - 1. Section 02320 - Backfill: Backfilling over filter aggregate.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M147 - Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses.
 - 2. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. ASTM International:
 - 1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m³).
 - 3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m³).
 - 4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 5. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate dimensions and layout of filter aggregate and filter fabric.
- C. Product Data: Submit data on filter aggregate and filter fabric products.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Operation and Maintenance Data: Procedures for submittals.



1.5 QUALITY ASSURANCE

- A. Furnish aggregate material and filter fabric from single source throughout the Work.
- B. Perform Work in accordance with the drawings and to the approval of the Engineer.

PART 2 PRODUCTS

2.1 AGGREGATE

- A. Filter aggregate (Gravel): Natural stone; washed, structurally and chemically stable; free of clay, shale, organic matter; graded to ASTM C136; to the following limits:
 - 1. $19.0 \text{ mm} < D_{85} < 35.0 \text{ mm}$.
 - 2. $11.2 \text{ mm} < D_{15} < 19.0 \text{ mm}$.

2.2 DRAINAGE PIPES

- A. Corrugated; perforated; PVC pipe factory; wrapped with coconut fiber (coco-fiber protection); as per approved standards.

2.3 ACCESSORIES

- A. Filter Fabric (Geotextile): Non-woven; non-biodegradable; made from polyolefin, polyester, or polyamide; 200 g/m²; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
 - 1. Grab Tensile Strength (ASTM D 4632) 900 N.
 - 2. Tear Strength (ASTM D 4533) 310 N.
 - 3. Puncture Resistance (ASTM D 4833) 490 N.
 - 4. Water Flow Rate (ASTM D 4491) 75 L/s/m².
 - 5. Apparent Opening Size (ASTM D 4751) 0.095 mm.

2.4 SOURCE QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services.
- B. Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D698, ASTM D1557, AASHTO T180, ASTM D4318, or ASTM C136.
- C. Fine Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D698, ASTM D1557, AASHTO T180, ASTM D4318, or ASTM C136.
- D. When tests indicate materials do not meet specified requirements, change material and retest.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.



- B. Verify trench cut and/or excavated base is ready to receive work, and excavations, dimensions, and elevations are as indicated on Drawings.

3.2 PREPARATION

- A. Hand trim excavations to required elevations. Correct over excavation with lean concrete and/or aggregate type as directed by the Engineer.
- B. Remove large stones or other hard matter which could damage drainage piping or impede consistent backfilling or compaction.

3.3 STOCKPILING

- A. Stockpile materials on site at locations indicated or designated by the Engineer.
- B. Stockpile in sufficient quantities to meet Project schedule and requirements.
- C. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.4 STOCKPILE CLEANUP

- A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

3.5 INSTALLATION

- A. Install Work in accordance with the drawings, to the manufacturer's instructions and to the satisfaction of the Engineer.
- B. Refer to Section 02320 for compaction requirements.

3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.

3.7 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.

3.8 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 02721

AGGREGATE SUB-BASE AND BASE COURSES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Aggregates for sub-base course.
 - 2. Aggregates for base course.
- B. Related Sections:
 - 1. Section 02320 - Backfill.
 - 2. Section 02339 - Sub-Grade Preparation.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
 - 2. AASHTO T193 - The California Bearing Ratio.
- B. ASTM International:
 - 1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m³).
 - 2. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
 - 3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m³).
 - 4. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 5. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal.
- B. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of aggregate to testing laboratory.
- C. Materials Source: Submit name of imported materials suppliers.
- D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

- A. Furnish each aggregate material from single source throughout the Work.

- B. Perform Work in accordance with the drawings and to Engineer's satisfaction.
- C. Maintain one copy of each document on site.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Aggregates for Sub-Base Course:
 - 1. Granular material for use in sub-base courses shall be a naturally occurring gravel, blended as necessary with fine or coarse material and screened to produce the specified gradation. Crushing of natural granular material shall not normally be required, unless for meeting the grading requirements, producing a higher quality sub-base with improved mechanical stability or when shown on the Drawings.
 - 2. Gravel shall consist of hard, durable and sound rock fragments, free from dirt, organic matter, shale and other deleterious substances.
 - 3. Granular materials for sub-base shall meet the requirement of class A or B as shown in Table-1, when tested in accordance with AASHTO T-27 after dry mixing and just before spreading and compacting. The class of granular material to be used shall be as shown on the Drawings or as selected by the Engineer. The actual gradation shall be continuous and smooth within the specified limits for each Class.
 - 4. Table-1: Grading of Granular Material by Class:

Sieve Designation (Square Openings)	Percent by Weight Passing	
	Class A	Class B
50 mm (2 in.)	–	100
25 mm (1 in.)	100	75 – 95
9.5 mm (3/8 in.)	30 – 65	40 – 75
4.75 mm (No. 4)	25 – 55	30 – 60
2.00 mm (No. 10)	15 – 40	20 – 45
0.425 mm (No. 40)	8 – 20	15 – 30
0.075 mm (No. 200)	2 – 8	5 – 20
 - 5. The material shall contain a maximum 5% clay content at any stage of construction when tested in the Hydrometer Test in accordance with AASHTO T88.
 - 6. The loss in weight of granular material shall not exceed 50% after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Abrasion Test).
 - 7. The granular material shall have a 4-day soaked CBR of not less than 30 when compacted at 100% of modified proctor AASHTO (T180-D) and tested in accordance with AASHTO T193.
 - 8. When tested for soundness in accordance with AASHTO T104, the material shall not show signs of disintegration and the percentage loss in weight after 5 cycles shall not exceed 12 % in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.
 - 9. The portion of granular material, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (LL) of not more than 25 and a plasticity index (PI) not greater than 6 when tested in accordance with AASHTO T 89 and T 90.



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

B. Aggregates for Base Course:

1. Aggregates for use in base course construction shall be either crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel or sand. Aggregate shall be washed if necessary to remove excessive quantities of clay, silty clay or salts.
2. Crushed stone shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter and shall contain not more than 8% of flat, elongated, soft or disintegrated pieces.
3. Crushed gravel shall consist of hard durable stones, rocks and boulders crushed to specified sizes and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt or other objectionable matter.
4. The method used in the production of crushed gravel shall provide a uniform material quality. The crushing of the gravel shall result in a product having at least 90% by weight of particles with at least one fractured face. All stones, rocks, and boulders of inferior quality occurring in the pit shall be discarded.
5. Any material passing the 4.75 mm (No. 4) sieve and produced in the crushing process may be incorporated in the base material up to the grading limits required for the base course aggregate.
6. Crushed aggregate for base course shall meet the requirements of Class A or Class B gradings as shown in Table-2 when tested in accordance with AASHTO T 27 after mixing with water, just before spreading and prior to compacting. The class of aggregate to be used shall be as shown on the Drawings or as selected by the Engineer. The actual grading shall be continuous and smooth within the specified limits for each Class. Gap graded aggregate shall not be accepted. If gradings are tested after compaction a tolerance of 3% shall be allowed in the upper limit for the percentage of material passing the 200 sieve.

7. Table-2: Grading of Base Course Aggregate by Class:

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

8. The amount of the fraction of material passing the No 200 mesh sieve shall not exceed one half of the fraction passing the No. 40 mesh sieve.
9. The loss in weight shall not exceed 45% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test) and the sand equivalent shall be a minimum of 43% when tested to AASHTO T176.
10. The crushed aggregate base course material shall have a 4-day soaked CBR of not less than 80 when compacted at 100% of modified proctor AASHTO (T180-D) and tested in accordance with AASHTO T 193.

11. When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and the loss by weight shall not exceed 12% in the case of the sodium sulphate test and 18% for the magnesium sulphate test.
12. The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a Liquid Limit (LL) of not more than 25 and Plasticity Index (PI) of not more than 6 when tested in accordance with AASHTO T 89 and T 90.
13. If additional fine material is required to correct the aggregate grading or for adjusting the LL or PI of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material at the crushing plant or by a method approved by the Engineer. Reworking of the material in situ to obtain the specified gradation shall not be permitted. Additional fine material shall only be obtained from the crushing of stone, gravel or natural material.

2.2 SOURCE QUALITY CONTROL AND TESTS

A. General Requirements: Quality requirements for testing, inspection and analysis.

B. Granular Sub-Base Course:

1. Sub-base course materials at source or at stockpile area shall be tested as specified. Materials laid and compacted shall be tested as shown in Table-3 below and, if found satisfactory, shall be approved by the Engineer. This approval shall not be deemed to constitute acceptance of sub-base course for payment purposes.
2. Compaction shall be tested in accordance with AASHTO T191 or AASHTO T205. If there is a delay between the construction of any layer and the following layer, if necessary and required by Engineer, the compaction of the lower layer shall be retested to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.
3. Table-3: Required Tests and Minimum Repetition for Sub-Base Course:

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

C. Granular Base Course:

1. Base course material shall be tested in accordance with Table-4 after in-situ compaction and if satisfactory shall be approved for use by the Engineer. This approval shall not be deemed to constitute acceptance of the base course for full payment purposes.



2. Compaction shall be tested in accordance with AASHTO T191, AASHTO T205. If there is a significant delay between the construction of any layer and the following layer, the Engineer may require the compaction of the lower layer to be retested to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.
3. Table-4: Required Tests and Minimum Repetition for Base Course:

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

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify substrate is dry and has been inspected and gradients and elevations are correct

3.2 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.
- B. Do not place fill on soft, muddy, or frozen surfaces.

3.3 AGGREGATE PLACEMENT

- A. Spread aggregate over prepared substrate to a total compacted thickness shown on the drawings or directed by the Engineer.
- B. Level and contour surfaces to elevations and gradients indicated.
- C. Add small quantities of fine aggregate to coarse aggregate to assist compaction.
- D. Maintain optimum moisture content of fill to attain required compaction density.
- E. Use mechanical tamping equipment in areas inaccessible to compaction equipment.



3.4 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation from Flat Surface: 6 mm measured with 3 m straight edge.
- C. Maximum Variation from Thickness: 4 mm.
- D. Maximum Variation from Elevation: 6 mm.

3.5 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Testing shall be performed as specified in this Specification Section.
- C. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

END OF SECTION



SECTION 02740

FLEXIBLE PAVEMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes asphaltic concrete binder and wearing courses, and surface sealer.
- B. Related Sections:
 - 1. Section 02230 - Site Clearing.
 - 2. Section 02320 - Backfill.
 - 3. Section 02339 - Sub-Grade Preparation.
 - 4. Section 02721 - Aggregate Sub-Base and Base Courses.

1.2 REFERENCES

- A. Asphalt Institute:
 - 1. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot- Mix Types.
 - 2. AI MS-19 - Basic Asphalt Emulsion Manual.
- B. ASTM International:
 - 1. ASTM D946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction.
 - 2. ASTM D3381 - Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit product information and mix design.
- C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

- A. Perform Work as per the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality, as specified, as shown on the drawings and to Engineer's satisfaction.
- B. Mixing Plant: Conform to relevant authorities' standards.
- C. Obtain materials from approved same source throughout the Work.
- D. Maintain one copy of each document on site.



1.5 QUALIFICATIONS

- A. Installer: Company specializing in performing work of this section with minimum ten years documented experience.

1.6 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements for environmental conditions affecting products on site.
- B. Do not place asphalt when ambient air or base surface temperature is less than 5°C, or surface is wet.

PART 2 PRODUCTS

2.1 MATERIALS - GENERAL

- A. All materials shall be in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.

2.2 BITUMINOUS PRIME AND TACK COATS

- A. General: Furnish and apply MC cutback bitumen prime coat to a previously constructed subgrade, aggregate base course, highway shoulders, or concrete pavement; and furnish and apply RC cutback bitumen or emulsified bitumen as a tack coat to a previously constructed bituminous base or wearing surface to provide a bond for a superimposed bituminous course.
- B. Medium-Curing Cutback Bitumen: MC cutback bitumen (for prime coats) shall be as recommended by ASTM D2399-83. MC 70 shall be used unless otherwise specified.
- C. Rapid-Curing Cutback Bitumen: RC cutback bitumen (for tack coats) shall be Grades RC-70 or RC-250 as appropriate, as specified and as shown on the Drawings.
- D. Slow-Curing Emulsified Bitumen: Slow-setting emulsified bitumen (for tack coats) shall be slow-setting Grade SS-1, SS-1h, CSS-1, or CSS-1h, as appropriate, as specified, and as shown on the Drawings.

2.3 AGGREGATES FOR BITUMINOUS PAVING MIXES

- A. Aggregates for use in bituminous base course, leveling course, macadam and cold mix courses shall consist of crushed rock or crushed gravel. Aggregates for use in wearing courses shall consist of crushed rock.
- B. Coarse aggregate shall be the fraction of crushed aggregate material retained on a 4.75 mm (No. 4) sieve. Fine aggregate shall be the fraction of crushed aggregate material passing a 4.75 mm (No. 4) sieve. Mineral filler shall be added when the combined grading of coarse and fine aggregates is deficient in material passing a 0.075 mm (No. 200) sieve.



- C. The material from hot bins passing the number 40 sieve (0.425mm) when tested in accordance with AASHTO T90 shall be non-plastic. In addition the material from cold bins shall not have a PI larger than 4.
- D. Aggregates shall not contain more than 1% gypsum and the coarse fraction of the aggregate shall not contain more than 5% chert.
- E. Aggregates shall be of uniform quality, free from decomposed stone, organic matter, and shale.
- F. The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T112.
- G. Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on a 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.
- H. The flakiness index and the elongation index tests shall be conducted in accordance with BS EN 933-3:1997 with the following maximum limits:

	Wearing Course	Binder and Base Course
Flakiness Index (FI).	20	35
Shape Index (SI).	25	30

- I. Aggregates shall be washed to remove any clay lumps, organic matter, adherent dust, clay film or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.
- J. Mineral filler shall consist of finely divided mineral matter such as limestone dust, hydrated lime, other non-plastic mineral filler free from clay and organic impurities and Portland cement, conforming to AASHTO M 17.
- K. Combined coarse and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T 27 and T11, shall conform to the grading shown in the following table.

SIEVE SIZE	PERCENT PASSING	
	Base Course	Wearing Course
1" (25.0 mm)	100	---
3/4" (19.0 mm)	65-100	100
3/8" (9.5 mm)	47-72	56-80
No. 4 (4.75 mm)	30-56	35-56
No. 10 (2.00 mm)	19-36	22-36
No. 40 (0.425 mm)	8-20	8-20
No.200 (0.075 mm)	2-8	2-8

- L. The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T 96, shall not exceed 35%.
- M. When tested for soundness in accordance with AASHTO T104 the coarse aggregate (retained on No.4 sieve) shall not show signs of disintegration and the loss by weight after 5 cycles shall not exceed 10% in the case of the sodium sulphate test and 12% in the case of the magnesium sulphate test.



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

2.4 BITUMEN PRODUCTS

- A. Penetration Graded Bitumen: Penetration graded bitumen shall conform generally to the requirements of AASHTO M 20 as given in the following table.

	Penetration Grade					
	40 -50		60 - 70		80 – 100	
	Min	Max	Min	Max	Min	Max
Ductility at 25°C (cm)	100	-	100	-	100	-
Penetration at 25°C (0.1 mm)	40	50	60	70	85	100
Softening Point (°C)	50	58	48	56	45.8	48
Specific Gravity at 25°C	1.01	1.06	1.01	1.06	1.0	-
Loss on heating 163°C	-	0.8	-	0.8	-	1.0
Penetration of residue % of original	58	-	54	-	50	-
Solubility in Trichloroethylene (% wt)	99	-	99	-	99	-
Ash content % wt	-	1.0	-	1.0	-	1.0
Flashpoint (Cleveland Open Cup) (°C)	250	-	250	-	225	-

- B. Sampling and testing shall be to AASHTO standard method listed in AASHTO M 20.
- C. The penetration bitumen application temperature range shall be determined to ensure that the appropriate viscosity range for each application is achieved. If the viscosity curves are not available the values given in the following table shall be used.

Bitumen Grade	40/50	60/70	80/100
Application Temperature °C	150-170	145-165	140-160

- D. The penetration grade for the project shall be either **60/70** or **80/100**.

2.5 BITUMINOUS BASE COURSE

- A. Job Mix: The job mix for bituminous base course shall conform to the following composition limits shown in the following:
1. Marshall Stability at 60°C: 700 kg.
 2. Flow: 2 - 3.5 mm.
 3. Minimum Voids in Mineral Aggregate (VMA): 12%.
 4. Air Voids: 4 – 8 %.
- B. Compacted Density: The compacted density of bituminous base course shall be equal to or greater than 97% of the average Marshall Bulk density for each day production.

2.6 BITUMINOUS WEARING COURSE

- A. Mix Design:
1. The bituminous mixture shall be designed using procedures contained in Chapter 5, Marshall Method of Mix Design, of the Asphalt Institute's Manual Series No. 2 (MS-2), sixth edition, and shall meet the following requirements:
 - a. Number of Blows: 75.
 - b. Stability: 900 kg.
 - c. Flow: 2 - 3.5 mm.



- d. Air Voids:
 - 1) 3% Normal Traffic (< 1 m ESAL).
 - 2) 4% Heavy Traffic (1- 5 m ESAL).
 - 3) 5% Very Heavy Traffic (>5 m ESAL).
- e. VFA:
 - 1) Normal to Heavy Traffic: 65 – 75%.
 - 2) Very Heavy Traffic: 65-73%.
- f. Dust to Bitumen Ratio: 1.2 maximum.
- g. Minimum Voids in Mineral Aggregate (VMA):

ASTM Sieve	Maximum Particle Size	Percent Design Air Voids		
(mm)	(mm)	3%	4%	5%
13	12.5	13 %	14 %	15 %
18	19.0	12 %	13 %	14 %
25	25.0	11 %	12 %	13 %
37	37.5	10 %	11 %	12 %

- 2. The Contractor shall prepare a series of test specimens with a range of different binder contents so that the test data show a well-defined curve. Tests shall be scheduled on the basis of 0.5% increments of binder content, with at least two binder contents above optimum and at least two below optimum.
- 3. Triplicate test specimens shall be prepared for each binder content mix to be tested.
- 4. The mineral aggregate shall be of such a size that the percentage composition by weight, as determined by laboratory sieves, shall conform to the gradation or gradations specified in the following table, when tested in accordance with ASTM C136 (dry sieve only). The percentage by weight for the bituminous material shall be within the limits specified.

ASTM Sieve Size	Percentage by Weight Passing Sieves		
38 mm	100	-	-
25 mm	90-100	100	-
18 mm	-	90-100	100
13 mm	56-80	-	90-100
Nº 4	-	56-80	-
Nº 8	29-59	35-65	44-74
Nº 16	19-45	23-49	28-58
Nº 30	-	-	-
Nº 50	-	-	-
Nº 100	5-17	5-19	5-21
Nº 200	1-7	2-8	2-10
Bitumen Content	4.5-7.0 %	5.0-7.5 %	5.5-8.0 %
Course Type	Binder	Binder or Wearing	Wearing

- 5. Bitumen content shall be calculated by weight of total mixture.
- 6. The compacted thickness of any layer shall be at least twice the maximum nominal size of the aggregate band for wearing course unless otherwise directed by the Engineer.
- 7. In considering the total grading characteristics of a bituminous paving mixture, a higher percentage of material passing the Nº 8 (2.36 mm) sieve will result in pavement surfaces having a comparatively fine texture, while coarse grading approaching the minimum amount passing the Nº 8 sieve will result in surfaces with comparatively coarse texture.



- B. Compacted Density: The compacted density of the bituminous wearing course shall be not less than 97% of the average Marshall Bulk Density for each day production.

2.7 ASPHALT PAVING MIX

- A. At least 30 days prior to the date the Contractor intends to begin production at the mixing plant and after receiving approval of the aggregates and delivery to the Site of the bitumen specified, the Contractor shall submit for the Engineer's approval his proposed Job Mix Formula.
- B. The Job Mix Formula shall stipulate a single combined grading of all aggregate and filler materials showing the specific percentages by weight passing each sieve size and of each material to be used in the total mix.
- C. The Job Mix Formula shall be established by the Contractor, under the supervision of the Engineer, in the field laboratory. Mix design procedures shall conform to the Marshall method of mix design and relevant procedures contained in Asphalt Institute Manual MS-2, Sixth Edition. All trial mixes shall be prepared and tested by the Contractor in the presence of the Engineer.
- D. The Job Mix Formula shall specify a combination of mineral aggregates including filler and bitumen (plus bitumen modifier if required) in such proportions to produce a Job Mix which is within the limits of the specified grading and bitumen content ranges and which meets the Marshall test requirements, as prescribed for each particular type of bitumen course. It shall also stipulate the mixing temperature at discharge from the mixer which, unless otherwise agreed by the Engineer, shall be 170°C.
- E. The Marshall Test procedure shall be used to determine the percentage of bitumen to be incorporated in the mix. The Job Mix Formula shall take into consideration the absorption of bitumen into the aggregates. Air voids shall be calculated in accordance with the procedure given in the Asphalt Institute Manual, MS-2.
- F. When compacting specimens in accordance with the Marshall Test procedure, the number of blows applied with the compaction hammer shall be 75 on each side, unless otherwise specified on the Drawings or instructed by the Engineer.
- G. In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid antistripping agent, may be used in the Job Mix. Portland cement shall meet the requirements of AASHTO M 85. Hydrated lime shall meet the requirements of ASTM C207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid antistripping agent shall be provided in the range of 0.6-1.0% by weight of the bitumen, or according to the manufacturer's specifications.



- H. Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to supply in the correct proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the job mix gradation limits given in the following table.

Sieve Designation (Square Openings)	Specified Tolerances
9.5 mm and above	+/- 5.0%
4.75 mm (No. 4)	+/- 4.0%
2.00 mm (No. 10)	+/- 4.0%
0.425 mm (No. 40)	+/- 4.0%
0.18 mm (No. 80)	+/- 4.0%
0.075 mm (No. 200)	+/- 1.0%
Bitumen Content	to be recommended by designer
Temperature of Mix on discharge	+/- 5°C

- I. Conformance to gradation requirements shall be determined on the extracted aggregate in accordance with AASHTO T30. The bitumen content shall be determined in accordance with AASHTO T164.
- J. The Engineer shall test the project mix at least twice daily during plant operation and, if necessary, direct the Contractor to readjust the plant to conform to the Job Mix Formula. If, due to differing cold feed or hot bin gradations, the Contractor cannot consistently produce a project mix meeting the Job Mix requirements, production shall cease, the Job Mix shall be redesigned and re-approved by the Engineer and the plant readjusted to produce a new Job Mix.
- K. The participation of the Engineer in the preparation of the Job Mix Formula shall not relieve the Contractor of his responsibility for producing project mixes meeting the specified requirements.

2.8 SPEED BUMPS

- A. Asphalted-Type Speed Bump:
1. Tack Coat: Liquid asphalt for tack coat shall be rapid curing type cutback grades RC-250 or RC-3000 as directed, and shall conform to the relevant requirements of Bituminous Prime and Tack Coats.
 2. Bituminous Mix: The bituminous mix for speed bumps shall conform to the relevant requirements of Bituminous Binder and Wearing Courses for a wearing course mix unless otherwise shown on the Drawings.
 3. Dimension: As shown on drawings.
- B. Paved-Type Speed Bump:
1. Paver Type: As shown on drawings, and as specified in Section 02783 and/or Section 02784.
 2. Dimension: As shown on drawings.

2.9 SOURCE QUALITY CONTROL AND TESTS

- A. General Requirements: Quality requirements for testing, inspection and analysis requirements.
- B. Submit proposed mix design of each mix class for review prior to beginning of Work.



- C. Test samples in accordance with AI MS-2, and in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or the Municipality.

- D. Minimum Tests Required for Bituminous Pavements at Source of Materials:

Item	Tests at Source of Materials	Frequency
Materials used in Asphalt Mix at Batching plant	1. Specific Gravity and Water Absorption. 2. Absorption Test. 3. Chert content. 4. Clay Lumps and Friable Particles. 5. Flaky and Elongated Particles. 6. Soundness.	For each source, and when material quality changes, and when requested by the Engineer
Materials Used in Asphalt Mix from Hot Bins	1. Gradation. 2. Specific Gravity and Water Absorption. 3. Plasticity Index. 4. Sand Equivalent. 5. Stripping with Asphalt.	For each source, and when material quality changes, and when requested by the Engineer
Asphalt Mix Design for Each Layer at Batching Plant	1. Complete Mix Design. 2. Loss of Stability.	For each Project, and when material quality changes, and when results are not consistent with the mix design results, and when requested by the Engineer
Asphalt for Each Layer at Batching Plant	1. Stability. 2. Flow. 3. Binder Content & Gradation. 4. Air Voids. 5. Voids in Mineral Aggregates. 6. Daily Marshall Density.	Every 3 working days, and for each batching plant, and when requested by the Engineer
	7. Loss of Stability.	Every week, and when requested by the Engineer

- E. Minimum Tests Required for Bituminous Pavements at Road Site:

Item	Test at Road Site	Frequency
Asphalt for Each Layer	Behind Spreader: 1. Stability. 2. Flow. 3. Binder Content & Gradation. 4. Air Voids. 5. Voids in Mineral Aggregates. 6. Marshall Density.	Every working day, and Test for each batch, and when requested by the Engineer
	Core Samples: 7. Density and Thickness. 8. Bitumen Penetration Grade Verification.	Every 200m per lane, and each layer, and when requested by the Engineer



- F. The Marshall Bulk specific gravity shall be determined in accordance with AASHTO T166. The Marshall specimens shall be prepared from the same material used in the construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the Site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.
- G. The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples or slab samples cut from each compacted layer on the road at locations selected by the Engineer. The Engineer reserves the right to instruct additional tests to determine the limits of areas deficient in density or for verification.
- H. Core samples for in-situ bulk specific gravity determination and verification of bitumen binder penetration grade shall be taken in sets of two from each pavement location. The minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placed bituminous layers.
- I. The Contractor shall cut the samples with an approved core drill in the presence of the Engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen.
- J. The Contractor shall, when necessary, furnish and apply cold water, ice, or other cooling substance to the surface of the pavement to prevent the sampling from shattering or disintegrating. The Contractor shall fill and compact all test holes at his own expense.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify compacted sub-grade, granular, or stabilized soil sub-base is dry and ready to support paving and imposed loads.
- C. Verify gradients and elevations of base are correct.
- D. Verify gutter drainage grilles and frames, manhole frames and the like are installed in correct position and elevation.

3.2 BITUMINOUS PRIME AND TACK COATS

- A. Construction of Trial Sections:
 - 1. The Engineer shall, if necessary, instruct trial sections to be constructed prior to the commencement of on-site prime or tack coat applications. The Contractor shall construct trial sections using varying application rates of bitumen as selected by the Engineer. Each trial section shall be two lanes wide by 50 meters long, at approved locations on or close to the Site.



2. Each trial section shall be constructed using the same materials, mixing and spraying equipment and construction procedures proposed for use in the Works.
 3. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment and the most suitable application rates for cutback bitumen prime and tack coats.
 4. The Contractor shall not proceed with site coat applications until the methods and procedures established in the trials have been approved by the Engineer.
- B. General Application Procedures:
1. All equipment used for surface cleaning, heating bitumen and application of prime and tack coats shall be suitable for the purposes intended and shall be approved by the Engineer before use.
 2. All surfaces to receive prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned using power brooms or power blowers. Surfaces shall be approved before applying any bitumen material.
 3. Prime coats and tack coats shall be applied only when the surface to be treated is sufficiently dry for tack coats and sufficiently moist for prime coats and when the ambient temperature is above 10°C for the application of tack coat and above 15°C for the application of prime coat. Prime and tack coats shall not be applied during fog, rain, strong winds, generally dusty conditions or dust storms.
 4. The surfaces of all structures, curbs, gutters and other highway appurtenances shall be protected from being splattered or stained with bitumen or damaged during equipment operation. The Contractor shall be responsible for making good any such staining or damage to the satisfaction of the Engineer.
 5. Traffic shall not be permitted on surfaces cleaned and prepared for prime or tack coat application.
 6. If there are undue delays in applying prime or tack coats or subsequent paving thereafter, the surface tolerances and compaction of the granular course shall be re-verified, the deficient areas shall be corrected and/or replaced, and the prime and tack coats shall be re-applied in accordance with the Engineer's instructions and at the Contractor's expense.
 7. The Contractor shall maintain prime coats and tack coats intact until they are covered by the subsequent pavement course. Any area where the coats have been damaged shall be cleaned of all loose material, all surface defects shall be repaired, and the coat shall be re-applied at the Contractor's expense.
- C. Prime Coat Application:
1. If required by the Engineer, when the surface is an untreated subgrade or a granular surface, the cleaned surface shall be given a light application of water and allowed to dry to the condition deemed appropriate by the Engineer before the bituminous material is applied.
 2. Heating of MC cutback bitumen and its temperature at the time of application shall be as specified.
 3. Areas to be primed shall be as shown on the Drawings and shall include 200 mm wide outside the edges of the pavement.
 4. Application rates for prime coat shall be determined by the Engineer from the trial sections and shall be generally within the following ranges:
 - a. Untreated subgrade surfaces, shoulders base course: 0.75-2.0 liter/m².

- b. Bridge wearing surfaces, concrete pavements: 0.1 - 0.4 liter/m².
 - c. Other Surfaces: As determined from field tests or trials.
- 5. The Engineer may order additional trial sections and/or alter the previously established rates of application during progress of the Works.
 - 6. Prime coat shall be applied using pressure distributors operated by skilled workmen. The spray nozzles and spray bar shall be adjusted and frequently checked so that a uniform distribution is ensured. Spraying shall cease immediately if any nozzle ceases to spray and corrective measures shall be taken before spraying is resumed.
 - 7. Hand spraying shall be used only for priming small patches or inaccessible areas that cannot be primed by normal operation of the pressure distributor.
 - 8. Application of prime coat between separate areas of priming shall not be excessive. Any excess prime coat shall be removed from the surface using clean sand to blot excess primer, and any skipped areas or recognized deficiencies shall be corrected using hand sprays.
 - 9. When required by the Engineer, a light covering of blotting material shall be applied to the prime coat 48 hours after spraying and when it has not dried sufficiently to withstand damage by traffic. The blotting material shall be a smooth fine sand or other material approved by the Engineer.
 - 10. Prime coats shall be cured for 3 days before traffic is allowed on it or before the succeeding pavement layer is placed, or as directed by the Engineer.

D. Tack Coat Application:

- 1. Tack coat application shall be as shown on the Drawings and on clean dry surfaces, and the application rate shall be as instructed by the Engineer. Emulsified bitumen shall be diluted and thoroughly mixed with an equal amount of water before application.
- 2. Heating of RC cutback bitumen and its temperature at the time of application shall be as specified. Where slow-curing emulsified bitumen (SS or CSS Type) is used for tack coat, it shall not require heating except in temperatures below 20°C.
- 3. The rate of application shall be approved by the Engineer between 0.1 and 0.6 kg/m² depending on whether RC cutback or emulsified bitumen is used, and on the surface condition of the bituminous course on which the tack coat is to be sprayed. The Engineer shall alter the previously established rates of application during progress of the Works if he deems it necessary.
- 4. The tack coat shall be allowed to dry only until it is in a suitable tacky condition to receive the superimposed bituminous course. Tack coat applications shall not proceed so far in advance of the following course that it dries out completely.
- 5. Spraying procedures shall be as specified for prime coat application.
- 6. Blotting material shall not be applied to tack coats.
- 7. Apply tack coat to contact surfaces of curbs, gutters and the like.
- 8. Coat surfaces of manhole and catch basin frames with oil to prevent bond with asphalt pavement. Do not tack coat these surfaces.

3.3 PLACING ASPHALT PAVEMENT - SINGLE COURSE

- A. Install Work in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.



- B. Place asphalt within 24 hours of curing primer coat.
- C. Place asphalt wearing course to compacted thickness shown on the drawings.
- D. Compact pavement by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- E. Perform rolling with consecutive passes to achieve even and smooth finish without roller marks.

3.4 PLACING ASPHALT PAVEMENT - DOUBLE COURSE

- A. Place asphalt binder course within 24 hours of curing prime coat. Place binder course to compacted thickness shown on drawings.
- B. Apply tack coat on binder course and allow to dry 2 hours before placing wearing course.
- C. Place wearing course within 8 hours of applying tack coat. Place wearing course to compacted thickness shown on the drawings.
- D. Compact each course by rolling to specified density. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.
- E. Perform rolling with consecutive passes to achieve even and smooth finish, without roller marks.

3.5 SPEED BUMPS

- A. Asphalted-Type Speed Bump:
 - 1. Prior to the application of the tack coat, the bituminous surface shall be cleaned free of all dirt, dust and other foreign substances which, in the opinion of the Engineer, would prevent proper bonding of the tack coat.
 - 2. Immediately after the surface has been cleaned and approved by the Engineer the tack coat shall be applied by pressure distributor, or by hand-spraying equipment which shall achieve uniform mist type coverage without blotches or streaks. The rate of application shall be between 0.2 and 0.3 liters per square meter unless otherwise required by the Engineer.
 - 3. When the tack coat has set and has been approved by the Engineer, the Contractor shall place the speed bump form in position. The hot bituminous mix shall be placed in the forms and consolidated by hand flush with the top of the form.
 - 4. After the bituminous mix has been placed in the form and consolidated, the form shall be carefully lifted and removed and rolling operations shall commence. Rolling shall be performed with a suitable type of pneumatic roller initially traveling parallel to the roadway centerline and finally at right angles to the centerline until the speed bump is compacted to the required cross section. The height of speed bumps above the pavement surface shall not exceed 100mm.
 - 5. Speed bump shall be painted with white reflectorized paint as shown on the drawings.



- B. Paved-Type Speed Bump:
 - 1. Install paving as specified in relevant paving section and as shown on the drawings.
 - 2. Speed bump shall be painted with white reflectorized paint as shown on the drawings.

3.6 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Flatness: Maximum variation of 6 mm measured with 3 m straight edge.
- C. Scheduled Compacted Thickness: Within 4 mm.
- D. Variation from Indicated Elevation: Within 6 mm.

3.7 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for field inspecting, testing, adjusting and balancing.
- B. Take samples and perform tests in accordance with AI MS-2, and in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.

3.8 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished work.
- B. Immediately after placement, protect pavement from mechanical injury for 24 hours or until surface temperature is less than 60°C.

END OF SECTION



SECTION 02631

STORMWATER DRAINAGE SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes stormwater drainage concrete channels.
- B. Related Sections:
 - 1. Section 02315 - Excavation.
 - 2. Section 02320 - Backfill.
 - 3. Section 03200 - Concrete Reinforcement.
 - 4. Section 03300 - Cast-in-Place Concrete.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
 - 2. AASHTO M36/M36M - Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
 - 3. AASHTO M86M - Concrete Sewer, Storm Drain and Culvert Pipe (Metric).
 - 4. AASHTO M170M - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric).
 - 5. AASHTO M196/M196M - Corrugated Aluminum Pipe for Sewers & Drains.
 - 6. AASHTO M198 - Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets.
 - 7. AASHTO M206M - Reinforced Concrete Arch Culvert Storm Drain, and Sewer Pipe (Metric).
 - 8. AASHTO M207M - Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe (Metric).
 - 9. AASHTO M252 - Corrugated Polyethylene Drainage Tubing.
 - 10. AASHTO M264 - Acrylonitrile-Butadiene-Styrene (ABS) and Poly Vinyl Chloride (PVC) Composite Sewer Piping.
 - 11. AASHTO M278 - Class PS 50 Polyvinyl Chloride (PVC) Pipe.
 - 12. AASHTO M288 - Geotextiles.
 - 13. AASHTO M294 - Corrugated Polyethylene Pipe, 12- to 36-in Diameter.
- B. ASTM International:
 - 1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
 - 3. ASTM C14M - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric).
 - 4. ASTM C76M - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric).
 - 5. ASTM C443M - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets (Metric).



6. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
7. ASTM C969 - Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines.
8. ASTM C969M - Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric).
9. ASTM C924 - Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method.
10. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m³).
11. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m³).
12. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
13. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
14. ASTM D2564 - Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems.
15. ASTM D2729 - Standard Specification for Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
16. ASTM D2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
17. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings.
18. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
19. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
20. ASTM D3034 - Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
21. ASTM D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Materials.
22. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

C. LIBNOR Standards.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Shop Drawings: Submit detailed shop drawings showing layout of each system, and connection details between different systems, if any.
- C. Product Data: Submit data indicating pipe and pipe accessories.
- D. Manufacturer's Installation Instructions: Submit special procedures required to install Products specified.
- E. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.



1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents:
 - 1. Accurately record actual locations of channels and pipes including runs, connections, manholes, inlets, outlets, and invert elevations.
 - 2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with local relevant authorities' standards, as shown on drawings and to the satisfaction of the Engineer.
- B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum five years documented experience.

1.7 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.8 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for transporting, handling, storing and protecting products.
- B. Block individual and stockpiled pipe lengths to prevent moving.
- C. Do not place materials on private property or in areas obstructing pedestrian or vehicle traffic.
- D. Do not place pipe flat on ground. Cradle to prevent point stress.
- E. Store UV sensitive materials out of direct sunlight.

1.9 COORDINATION

- A. General Requirements: Administrative requirements for coordination.
- B. Coordinate unrecorded or variations in site conditions, and corresponding adjustments to construction requirements.



PART 2 PRODUCTS

2.1 MATERIALS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Furnish materials as specified, as shown on the drawings, to the satisfaction of the Engineer, and in accordance with local relevant authorities' standards.

2.2 STORMWATER DRAINAGE CHANNELS

- A. Concrete: As specified in Section 03300.
- B. Reinforcement: As specified in Section 03200.
- C. Bituminous Paint to Concrete External Surfaces in Contact with Soil: Fluid, cold applied, quick setting. Primer type shall be compatible with the bituminous paint.
- D. Cast-In-Situ or Precast Concrete Covers: As specified in Section 03300; size and shape as directed by the Engineer.

2.3 BACKFILL MATERIALS

- A. Soil Backfill above Pipe Cover to Finish Grade: As specified in Section 02320.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify trench cut and excavation base is ready to receive work and excavations, dimensions, and elevations are as indicated on drawings.

3.2 PREPARATION

- A. Hand trim excavations to required elevations. Correct over excavation with lean concrete.
- B. Remove large stones and other hard or organic matter capable of damaging piping or impeding consistent backfilling or compacting.

3.3 EXCAVATION

- A. Excavate trenches for concrete channels in accordance with Section 02315.
- B. Hand trim excavation for accurate placement of earth channels, pipe, box culvert and concrete channels to elevations indicated.



- C. Remove water entering the site to maintain dry conditions and to preserve final grades at bottom of excavation.
- D. Provide sheeting and shoring, if required, in accordance with Section 02315.

3.4 INSTALLATION - CONCRETE CHANNEL

- A. Cast-in-place plain concrete for foundation beds and reinforced concrete channels in accordance with Section 03300.
- B. Prime and paint exterior surfaces in contact with soil with two cross coats of an approved bituminous paint. Spread to a minimum cured thickness and averaging thickness as recommended by the manufacturer.
- C. Install precast concrete covers and metal gratings (if any) with all necessary supports, angles, anchors and accessories.

3.5 BACKFILLING

- A. Backfill at sides of concrete channel to finished grade as per Section 02320.
- B. Maintain optimum moisture content of bedding to attain required compaction density.

3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Request inspection prior to and immediately after placing pipe cover.
- C. Compaction Testing: In accordance with Section 02320.
- D. When tests indicate work does not meet specified requirements, remove work, replace and retest.
- E. Pipe Infiltration Test: Test in accordance with ASTM 969M.
- F. Pipe Deflection Test: Test in accordance with approved standard.
- G. Pipe Pressure Test: Test in accordance with ASTM C924 and ASTM 1103M, depending on size of pipe.

3.7 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished Work.
- B. Protect each stormwater drainage system from damage and/or displacement prior, during and until backfilling operation is complete. Repair channel and pipe that are damaged and/or displaced.

END OF SECTION



SECTION 02811

LANDSCAPE IRRIGATION

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Automatic irrigation system.
 - 2. Manual irrigation system.
- B. Related Sections:
 - 1. Section 02315 - Excavation.
 - 2. Section 02320 - Backfill.
 - 3. Section 02923 - Landscape Grading.
 - 4. Division 15 - Mechanical.
 - 5. Division 16 - Electrical: Electrical power supply, installation and connection for equipment.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM D2241 - Standard Specification for Poly Vinyl Chloride (PVC) Pressure-Rated Pipe (SDR Series).
 - 2. ASTM D2466 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40.
 - 3. ASTM D2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.
 - 4. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
 - 5. ASTM D2564 - Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems.
 - 6. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings.
- B. National Electrical Manufacturers Association:
 - 1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. Plastic Pipe Institute:
 - 1. PPI Technical Report TR31.
- D. American National Standard Institute:
 - 1. ANSI B16.5 Pipe Flanges and Flanged Fittings.

1.3 SYSTEM DESCRIPTION

- A. Automatic irrigation system comprising the following:
 - 1. Water storage tank.
 - 2. Irrigation pumps set and equipment.



3. Automatic irrigation system including drip emitters, sprinklers, electric solenoid valves, electronic controller and piping.
 4. Electric power supply and a low voltage control of 24 Volts.
 5. Trees, shrubs and ground covers shall have each separate programs.
- B. Manual irrigation system comprising the following:
1. Water storage tank.
 2. Irrigation pumps set and equipment.
 3. Manual irrigation system including quick coupling valves, fittings, hoses, accessories, connection to main line, etc.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate piping layout to water source, location of sleeves under pavement, location and coverage of sprinkler heads, sprayer, saddle, dripper, valves, timer program, control panel, water connector, components, plant and landscaping features, site structures, outlets and fittings.
- C. Product Data: Submit component and control system and wiring diagrams.
- D. Samples: Submit one outlet of each type, with housing.

1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Record actual locations of concealed components, piping system, conduit, etc.
- C. Operation and Maintenance Data:
1. Submit instructions for operation and maintenance of system and controls, seasonal activation and shutdown, and manufacturer's parts catalog.
 2. Submit schedule indicating length of time each valve is required to be open to deliver determined amount of water.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum five years documented experience.

1.7 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene one week prior to commencing Work of this section



1.8 FIELD MEASUREMENTS

- A. Verify field measurements are as indicated on approved shop drawings, as instructed by manufacturer and to the satisfaction of the Engineer.

1.9 COORDINATION

- A. General Requirements: Administrative requirements for coordination.
- B. Coordinate Work with site backfilling, landscape grading and delivery of plant life.

1.10 EXTRA MATERIALS

- A. General Requirements: Execution requirements for extra materials.
- B. Furnish the following:
 - 1. Two sprinkler heads of each type and size.
 - 2. Two valve keys for manual valves.
 - 3. Two valve box keys.
 - 4. Two keys for valve markers.
 - 5. Two wrenches for each type head core and for removing and installing them.

PART 2 PRODUCTS

2.1 AUTOMATIC AND MANUAL IRRIGATION SYSTEMS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Furnish materials as specified, as per manufacturer's recommendations, to the satisfaction of the Engineer, and in accordance with local relevant authorities' recommendations and standards.

2.2 PIPE MATERIALS

- A. Polyethylene Pipe (PE): ASTM; Working pressure 1380 kPa, PE pipes shall be cut with an approved mechanical pipe cutter and in conformity with pipe manufacturer's recommendations. Where the cut end of the pipe is to be incorporated in a joint the pipe shall be turned down to the correct diameter required for forming the joint by an approved mechanical turning machine. The length of turning shall be sufficient to enable the joint to be properly made. The ends of the pipe shall be accurately beveled by mechanical means to the dimensions specified in the manufacturer's recommendations and as required to suit the form of joint used.
- B. Poly Vinyl Chloride (PVC) Plastic Pipe Up to 300 mm Diameter: ASTM D2241; inside nominal diameter as shown on drawings, bell and spigot style solvent sealed joint ends.
 - 1. Fittings: ASTM D2466, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
- C. Fittings (Connector Elbows, Tees, etc.): Type and style of connection to match pipe.



2.3 OUTLETS

- A. Outlets: Brass or bronze construction.
- B. Rotary Type Sprinkler Head: Fixed, or Pop-up type with screens; fully adjustable for flow and pressure, with letter or symbol designating degree of arc and arrow indicating center of spray pattern.
- C. Spray Type Sprinkler Head: Fixed surface head, or pop-up head pattern as selected by the Engineer (full circle, half circle, third circle, quarter circle, and/or square pattern).
- D. Emitter: Adjustable outlet, non-clogging.
- E. Bubbler: Adjustable outlet.
- F. Quick Coupler.

2.4 MANUAL VALVES

- A. Gate and Ball Valves: Bronze construction, non-rising stem, or inside screw with threaded ends.
- B. Backflow Preventers: Iron, or bronze body construction, and double check valve, reduced pressure zone or atmospheric type.
- C. Valve Box and Cover.
- D. Drain Valve.

2.5 CONTROLS AND CONTROL VALVES

- A. Controller: Automatic controller, microprocessor solid state control with visible readout display with relay switches, temporary override feature to bypass cycle for inclement weather, timer for the required station system, programmable for 14 days in quarter hour increments, with automatic start and shutdown.
- B. Controller Housing: NEMA 250 Type 4; weatherproof, watertight, with lockable access door.
- C. Valves: Hydraulic, Electric Solenoid, or Thermal Hydraulic; open or closed; hydraulic tubing, wiring, including required fittings and accessories.
- D. Copper conductor, direct burial type.

2.6 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. Electrical Characteristics: In accordance with Division 16 - Electrical.
- B. Disconnect Switch: Factory mount disconnect switch in control panel or on equipment.



- C. Control Panel Enclosures:
 - 1. Product Description: Cabinet conforming to NEMA ICS 6.
 - 2. Shop fabricate control panels to NEMA ICS 1.
 - 3. Boxes: Galvanized steel with removable end walls.
 - 4. Box Size: 600 mm wide x 800 mm high x 150 mm deep.
 - 5. Backboard: Furnish 18 mm thick plywood backboard for mounting terminal blocks. Paint matte white.
 - 6. Fronts: Steel, surface type with concealed trim clamps, door with concealed hinge, and flush lock keyed to match branch circuit panelboard. Finish with gray baked enamel.
 - 7. Furnish metal barriers to form separate compartments for wiring of different systems and voltages.
 - 8. Furnish accessory feet for free-standing equipment.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify location of existing utilities.
- C. Verify required utilities are available, in proper location and ready for use.

3.2 PREPARATION

- A. Piping layout indicated is diagrammatic only. Route piping to avoid plants, ground cover, and structures.
- B. Layout and stake locations of system components.
- C. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system.

3.3 TRENCHING

- A. Trench in accordance with Section 02315, and as per approved shop drawings.
- B. Trench to accommodate grade changes and slope to drains.
- C. Maintain trenches free of debris, material, or obstructions damaging to pipe.

3.4 INSTALLATION

- A. Connect to utilities.
- B. Set outlets and box covers at finish grade elevations shown on approved shop drawings.
- C. Provide for thermal movement of components in system.



- D. Slope piping for self drainage to filter aggregate.
- E. Use threaded nipples for risers to each outlet.
- F. Install control wiring in accordance with Division 16. Provide 250 mm expansion coil at each control valve, and at 30 m intervals. Bury wire and tubing beside pipe. Mark valves with neoprene valve markers containing locking device. Set valve markers in approved polyethylene pipe risers exiting from top of valve to finish grade.
- G. After piping is installed, but before outlets are installed and backfilling commences, open valves and flush system with full head of water.
- H. Coordinate water storage tank, and irrigation pumps set and equipment installations with Division 15.
- I. Coordinate pipe installation with Division 15.
- J. Coordinate electrical power supply and installations with Division 16.

3.5 BACKFILLING

- A. Install 75 mm sand cover over piping.
- B. Refer to Section 02320 for backfilling requirements.
- C. Protect piping from displacement.

3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Prior to backfilling, test system for leakage for whole system to maintain 690 kPa pressure for one hour.
- C. System is acceptable when no leakage or loss of pressure occurs and system self drains during test period.
- D. Provide one complete Spring season start-up and Fall season shutdown.

3.7 ADJUSTING

- A. General Requirements: Execution requirements for testing, adjusting and balancing.
- B. Adjust control system to achieve time cycles required.
- C. Change and/or adjust head types for full water coverage as directed by Engineer.

3.8 DEMONSTRATION AND TRAINING

- A. General Requirements: Execution requirements for demonstration and training.



- B. Instruct Owner's personnel in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance material as basis for demonstration.

3.9 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 02820

FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Painted steel fence fixed to concrete parapets and all necessary accessories.
- B. Related Sections:
 - 1. Section 02315 - Excavation.
 - 2. Section 02320 - Backfill.
 - 3. Section 03300 - Cast-in-Place Concrete.
 - 4. Section 05500 - Metal Fabrication.
 - 5. Section 09220 - Portland Cement Plaster.
 - 6. Section 09900 - Paints and Coatings.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 3. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 5. ASTM B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
 - 6. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
 - 7. ASTM F900 - Standard Specification for Industrial and Commercial Swing Gates.
 - 8. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
 - 9. ASTM F1184 - Standard Specification for Industrial and Commercial Horizontal Slide Gates.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Shop Drawings: Indicate plan layout, spacing of components, parapets, foundation dimensions, hardware anchorage, gates, and schedule of components.
- C. Product Data: Submit data on posts, accessories, fittings and hardware.
- D. Samples: Submit two samples of metal fence illustrating construction and finish.
- E. Manufacturer's Installation Instructions: Submit installation requirements.



1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.
- B. Project Record Documents: Accurately record actual locations of parapet and foundations.
- C. Operation and Maintenance Data: Procedures for submittals.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with approved standards, as shown on the drawings and to the satisfaction of the Engineer.
- B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum five years documented experience.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 COMPONENTS

- A. Metal Fence: As specified in Section 05500.
- B. Concrete Parapet and Foundations: As specified in Section 03300.
- C. Plastering Work: As specified in Section 09220.
- D. Painting: As specified in Section 09900.

2.3 ACCESSORIES

- A. All accessories including fasteners and anchors, adhesive, sealer, etc., shall be to manufacturer's recommendations.

2.4 GATES

- A. General:
 - 1. Gate Types, Opening Widths and Directions: As per approved shop drawings.
 - 2. Design and factory assemble gates.



PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrate and conditions under which the fences and gates shall be installed.
- B. Verify substrate is ready to receive the fence.
- C. Establish elevations and complete grading work.
- D. Correct any unsatisfactory conditions. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.2 INSTALLATION

- A. Install work as specified, as shown on approved shop drawings, as per manufacturer's instructions, in accordance with local relevant authorities' standards, and to the satisfaction of the Engineer.

3.3 ERECTION TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation from Plumb: 6 mm.
- C. Maximum Offset from Indicated Position: 25 mm.
- D. Minimum distance from property line: 150 mm.

3.4 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 02923

LANDSCAPE GRADING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes final grade topsoil for finish landscaping.
- B. Related Sections:
 - 1. Section 02320 - Backfill.

1.2 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures
- B. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of fill to testing laboratory.
- C. Materials Source: Submit name of imported materials source.
- D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.3 QUALITY ASSURANCE

- A. Furnish each topsoil material from single source throughout the Work.
- B. Perform Work in accordance with the drawings and to the approval of the Engineer.
- C. Maintain one copy on site.

PART 2 PRODUCTS

2.1 MATERIAL

- A. Agricultural Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; minimum pH value of 5.4 and maximum 7.0; organic matter to exceed 1.5%, magnesium to exceed 100 units; phosphorus to exceed 150 units; potassium to exceed 120 units; soluble salts/conductivity not to exceed 900 ppm/0.9 mmhos/cm in soil.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.



- B. Verify building and trench backfilling have been inspected.
- C. Verify substrate base has been contoured and compacted.

3.2 PREPARATION

- A. Protect landscaping and other features remaining as final Work.
- B. Protect existing structures, fences, sidewalks, utilities, paving and curbs (if any).

3.3 SUBSTRATE PREPARATION

- A. Eliminate uneven areas and low spots.
- B. Remove debris, roots, branches, stones, in excess of 13 mm in size. Remove contaminated subsoil.
- C. Scarify surface to depth of 150 mm where topsoil is scheduled. Scarify in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.4 PLACING TOPSOIL

- A. Place topsoil in areas where seeding, sodding and planting is required and to the required thickness. Place topsoil during dry weather.
- B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.
- C. Remove roots, weeds, rocks and foreign material while spreading.
- D. Manually spread topsoil close to plant material or to building to prevent damage.
- E. Lightly compact or roll placed topsoil as directed by the Engineer.
- F. Remove surplus subsoil and topsoil from site.
- G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.5 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Top of Topsoil: Plus or minus 13 mm.

3.6 PROTECTION OF INSTALLED WORK

- A. General Requirements: Execution requirements for protecting finished Work.
- B. Prohibit construction traffic over topsoil.

END OF SECTION



SECTION 02930

EXTERIOR PLANTS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes excavation for landscaped areas and pit excavation for tree plantation; filter gravel materials and filter fabric (geotextile); agricultural topsoil; trees, shrubs, plants, ground cover and lawn plantation; mulch; fertilizer; pruning; and maintenance.
- B. Related Sections:
 - 1. Section 02315 - Excavation.
 - 2. Section 02320 - Backfill: Rough grading of site.
 - 3. Section 02620 - Subdrainage: Gravel materials under landscaped areas.
 - 4. Section 02923 - Landscape Grading: Preparation of subsoil and placement of topsoil in preparation for the Work of this section.

1.2 REFERENCES

- A. American National Standards Institute:
 - 1. ANSI A300 - Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance - Standard Practices.
 - 2. ANSI Z60.1 - Nursery Stock.

1.3 DEFINITIONS

- A. Plants: Living trees, plants and ground cover specified in this Section, shown on the drawings, and as described in ANSI Z60.1.
- B. Height of tree shall mean the trunk height of the tree.
- C. Each shrub and ground cover shall have multiple branches (at least five branches).

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit list of plant material sources, data for fertilizer and other accessories.
- C. Submit minimum 280 g sample of topsoil proposed. Forward sample to testing laboratory in sealed containers to prevent contamination.

1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.



- B. Operation and Maintenance Data: Include pruning objectives, types and methods; types, application frequency, and recommended coverage of fertilizer.

1.6 QUALITY ASSURANCE

- A. Tree Pruning: ANSI A300 Pruning Standards for Woody Plants.
- B. Perform Work in accordance with the drawings, to the instructions of the supplier and manufacturer, and to the approval of the Engineer.
- C. Maintain one copy of each document on site.

1.7 QUALIFICATIONS

- A. Nursery: Company specializing in growing and cultivating plants with ten years documented experience.
- B. Installer: Company specializing in installing and planting plants with five years documented experience.
- C. Tree Pruner: Company specializing in performing work of this section with minimum five years documented experience.
- D. Maintenance Services: Performed by installer.

1.8 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.9 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for transporting, handling, storing and protecting products.
- B. Deliver fertilizer in waterproof bags showing weight, chemical analysis and name of manufacturer.
- C. Protect and maintain plant life until planted.
- D. Deliver plant life materials immediately prior to placement. Keep plants moist.
- E. Plant material damaged as a result of delivery, storage or handling will be rejected.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements for environmental conditions affecting products on site.
- B. Do not install plant life when ambient temperatures may drop below 5°C or rise above 35°C.



- C. Do not install plant life when wind velocity exceeds 48 km/hr.

1.11 COORDINATION

- A. General Requirements: Administrative requirements for coordination.
- B. Install plant life after and coordinate with installation of underground irrigation system piping and watering heads.

1.12 WARRANTY

- A. General Requirements: Execution requirements for warranties.
- B. Furnish one-year manufacturer warranty for trees, plants and ground cover.

1.13 MAINTENANCE SERVICE

- A. General Requirements: Execution requirements for maintenance service.
- B. Maintenance to Certificate of Completion:
 - 1. All planted areas within the contract boundary shall be maintained and guaranteed from the time of planting until the issue of Certificate of Completion.
 - 2. Maintenance shall include but not be limited to watering, weeding, cultivating, control of insects, or diseases by means of spraying with approved insecticides, herbicide, fungicide, pruning, adjustment and repair of anchors and wire, repair of minor washouts and other horticultural operations necessary for the proper growth of plants and for keeping the contract area neat in appearance.
 - 3. Where planting is extended over more than one season, during summer months or at any other period when weather conditions do not permit planting to be carried out, all areas where planting soil mix has been spread shall be maintained. This shall include, where necessary, watering and shall apply to all incomplete work.
- C. Maintenance after Certificate of Completion:
 - 1. After Certificate of Completion has been issued, all planted areas shall be maintained and guaranteed through the maintenance period.
 - 2. Maintenance operations shall be performed during this period as specified and as required, and to the satisfaction of the Engineer.
- D. Tree Maintenance Operations:
 - 1. Irrigation:
 - a. Water as necessary at approved rate and time, preferably at night or early or late in the day. Avoid inadequate and excessive applications of irrigation water and limit to quantities required for plant development. Leach as necessary at approved timing and rate subject to site and species. Maintain irrigation basins by removing all debris, weeds, and blown material.
 - 2. Pruning:
 - a. Under the direction of the Engineer allow for cutting back of certain types of trees to encourage formation of crown. Limit amount of



pruning to minimum necessary to encourage proper growth, to remove dead or injured twigs and branches, and to compensate for result of transplanting operations. Prune in such a manner as not to change natural habit or shape of tree unless otherwise authorized. Make cuts flush leaving no stub.

E. Shrub, Vine and Ground Cover Maintenance Operations:

1. Irrigation:

- a. Water as necessary at approved rate and timing, preferably at night or early or late in the day. Avoid excess applications of irrigation water and limit to quantities required for plant development. Leach as necessary at approved timing and rate subject to site and species. Maintain irrigation equipment to required standard.

2. Fertilizer Application:

- a. Apply balanced liquid fertilizer and if necessary combine with a slow release fertilizer. Apply to manufacturer's instructions in September and December.
- b. Give annual application of 25g/m² of approved phosphate fertilizer and if necessary, combined fertilizer each at specified rate. Apply dry and water in well. To be applied in February or March each year.

3. Weeding and Hoeing:

- a. All vine pockets and shrubs borders shall be hoed, forked or hand weeded where appropriate and all areas kept clear of weeds. Remove all debris or other refuse. Trodden ground to be hoed, forked or raked over as necessary.

4. Pruning:

- a. Cut back shrubs in early Spring to encourage bushiness. With the exception of hedges and ground cover plants, shrubs shall be pruned to maintain natural shape. Shrub species with a significant display of flowers shall not be pruned after the formation of lower buds until completion of the flowering season.
- b. Shrubs will generally be pruned to encourage a good bushy effect in keeping with their natural characteristics. Where there is a tendency, natural or otherwise, for the plant to develop leggy, coarse growth, it can generally be hard pruned at the outset of the main growing season, all to encourage strong new growth. Consideration must be given to situations where shrubs are fulfilling a screening purpose and here they should be pruned less hard. In general, all dead growth must be removed as it appears.
- c. On all cuts over 25mm in diameter and on bruises or scars on bark, trace back injured cambium to living tissue and remove. Smooth wounds with a sharp knife to avoid retention of water and coat treated area with approved tree sealant in accordance with BS 3998 or equal.
- d. Pruning shall generally be carried out in the winter or period of dormancy, and only by skilled horticulturists or under their direct supervision. At no time shall the terminal leader of trees be removed and if this is damaged, the Contractor should endeavor to train a replacement.
- e. Climbing plants will usually only be pruned to remove dead wood and to control their growth in the direction/manner that is required.



Where growth is too vigorous, plants can usually be pruned hard to control them and to encourage fresh new growth.

5. Protection:
 - a. Maintain all fencing around plantations, screens or protection to individual trees as necessary. Maintain Hessian wrapping to trees as necessary.
6. Hard Areas Bordering Trees:
 - a. Maintain paving or other hard surfaces that may become removed or loosened by growth of trunk or root system of trees.
7. Tree Ties:
 - a. Loosen or remove tree ties in accordance with growth of trunk to avoid constriction of growth.
8. Replacement Stakes, Canes or Ties:
 - a. Replace stakes and fix new ties to climbers as described.
9. Pest and Disease Control:
 - a. Specific checks for pests and disease to be carried out every month by a trained member of staff.
 - b. All equipment should be surface sterilized (with methylated spirits) after use on the plants which are known, or suspected to be diseased. All diseased wood, fungi, prunings, etc., to be burned after removal from diseased plants. (Methods and location of burning must be approved by the Owner).
10. Micro-Nutrients:
 - a. Corrective foliar sprays of the micro-nutrients shall be applied to plants on the identification of deficiency symptoms. 1/12 kg/ha of manganese or manganese sulphate to be sprayed to deficient plants and sprays re-applied at intervals of approximately two weeks until deficiency is alleviated. 100g of chelated iron/100 liters of water to be sprayed to counteract iron deficiency and be repeated at two-weekly intervals. A foliar spray of zinc at 265 g of zinc /100 liters of water shall be sprayed at intervals only with proper safeguard and at such times to ensure that there is no human contact with the spray. The Contractor shall ensure that the spray does not contaminate any food crops. The Contractor shall be responsible for ensuring that the micro-nutrient concentrations and methods of application are not hazardous to human or animal health and shall present his Spraying Programme and necessary precautions to the Owner for approval prior to commencement of operations.
11. Herbicide:
 - a. Contact herbicide shall be based on paraquat/ diaquat and systemic herbicide based on glyphosphate, for all planted areas.
12. Chemicals:
 - a. Fertilizers, pesticides, herbicides and fungicides to be used must have Owner approval. Products must conform with the agricultural chemicals and the agricultural departments of the country of manufacture. Chemicals will be applied according to the manufacturer's recommendations ensuring safety at all times to humans and animals and to avoid contamination to any water source, food crops or surrounding areas.



13. Irrigation Maintenance:
 - a. Irrigation equipment shall be maintained. Each emitter and sprinkler head shall be checked after planting and then weekly for first six months of maintenance period and thereafter monthly until the end of the maintenance period.
- F. Maintenance Operations of Grass Areas:
 1. General:
 - a. Maintenance shall consist of watering, weeding, cutting, repair to all erosion and settlement, and replanting as necessary to establish a uniform and healthy stand of the specified grasses.
 2. Mowing:
 - a. Mow grass with an approved machine at intervals, not less than every 14 days. In the summer the interval between mowing shall be 5-7 days or as required to avoid sun scorch. Cutting height shall avoid a scalped appearance and minimize thatch build-up. Grass height as approved or directed by Engineer. All grass clipping should be collected.
 3. Replanting:
 - a. All grassed areas, subject to die back from tree shading as trees mature, shall be re-sodded.
 4. Fertilizer Application:
 - a. Prior to irrigation, give top dressing of 25g/m² every three months of approved quantities of nitrogen fertilizer applied dry, evenly and mixed with fine washed sand. Apply, in alternation, approved compound fertilizer every three months.
- G. General Maintenance:
 1. Fertilizer Application:
 - a. Apply fertilizer as necessary to particular site. Normally give annual application of phosphate fertilizer and if necessary combined slow release fertilizer each at specified rate. Apply dry and water well. To be applied in February or March.
 - b. The following rates and timings are subject to adjustment based on analysis and the Contractor's judgment. Analysis is to be carried out quarterly starting in January of each year. Soil samples will be taken in the accepted manner and at interval distances as necessary to provide a true picture of nutrient levels over a given area.
 - c. Compound Fertilizers:
 - 1) Compound Slow Release Fertilizer (drilled) 18/11/10, 9 month formulation, or similar. Applied in February and September at rate of 50 grams per m² and lightly cultivated into top 50mm of soil.
 - 2) Compound Slow Release planting tablets (urea formaldehyde base) placed directly into soil at 100-200 mm depth in direct vicinity of irrigation emitters. One 10 gram tablet per 1 cm of tree diameter and two 10 gram tablets per m² of foliage cover for shrubs, flowers and groundcover. Tablets should be 10/10/5 (or similar), two year formulation and shall be applied in March.



- d. Nitrogen Supplements:
 - 1) Urea formaldehyde, minimum 50% water soluble, broadcast as required at rate of 30 grams per m² and cultivated into surface soil. Alternatively applied as a foliar spray at rate of 2 grams per liter.
 - 2) Ammonium sulphate 21/0/0, broadcast as required at rate of 40 grams per square meter and watered in by hosepipe. Alternatively applied as a liquid feed at rate of 2 grams per liter.
- e. Phosphatic Fertilizer:
 - 1) Single superphosphate 0/18/0, applied at rate of 120 g/m².
- f. Iron Supplement:
 - 1) Sequestrene applied overall in February and June at rate of 2 grams per m² or as a foliar spray at 1 gram per liter.
 - 2) Iron chelate applied as a solution to chlorotic plants as required.
- g. Zinc Supplement:
 - 1) As foliar spray of zinc at 265gm of zinc per 100 liters of water as required.
- h. Management Supplement:
 - 1) 1.12kg/ha of manganese or manganese sulphate to be sprayed to deficient plants and sprays re-applied after intervals of approximately two weeks until deficiency is alleviated.
- 2. Weeding and Hoeing:
 - a. Maintain areas close to base of trees from weed within one meter of plants. Maintain soil surface and control weeds by regular cultivation at approximately 3 month intervals.
 - b. Paths and areas to be kept free of all vegetation can be controlled by weedkiller based on “Simazine” or equal.
 - c. Pesticides and Fungicides:
 - 1) Pest control sprays must contain only chemicals acceptable for use in amenity horticulture (e.g. Pyrethrum).
 - 2) Fungicide sprays must contain only chemicals acceptable for use in amenity horticulture, such as copper or sulphate. This need not apply to fungicide drenches.
 - d. Disease and Pest Control:
 - 1) The Contractor will instigate a pest control programme from the beginning of his contract. Spraying is advisable only very early in the day, to prevent damage to plants. It is also a time when movement of people is at minimum. Due consideration must be given at all times to protecting people and surfaces from ill effects of spraying.
 - 2) Specific checks for pests and disease shall be carried out every month by a trained member of staff.
 - 3) All equipment should be surface sterilized (using an approved disinfectant such as methylated spirit) after use on the plants which are known, or suspected to be diseased. All diseased wood, fungi, pruning, etc., shall be burned after removal from diseased plants. (Methods and location of burning shall be submitted to the Engineer for approval).



- 4) Approved fertilizers, pesticides, herbicides and fungicides only shall be used. Chemicals will be applied according to manufacturer's recommendations, ensuring safety at all times to humans and animals, and shall avoid contamination of any water source, food crops or surrounding areas.
- 5) Control of disease will be largely affected by general cleanliness in operations and by consistent observation of plants.
- 6) As soon as any disease symptoms are noted the Contractor should carry out drenching or spraying to prevent the disease spreading to healthy plants.
- 7) All plants which do not respond to treatment shall be removed and burned at a location approved by the Engineer, and the soil mix excavated and replaced before replanting. Pruning, rubbish and suspect plant material should be removed from site quickly at all times and burned at a location approved by the Engineer.
- e. Weed Control:
 - 1) Areas close to base of plants shall be kept free from weeds within 1m of plants. Maintain soil surface and control weeds by regular cultivation at approximately one monthly interval.
 - 2) Generally, Contractor will rely on hand cultivations close to and round trees and plants and throughout close planted areas. In the lawn area, like shelter-belts, chemical weed control can be carried out if permitted.
- f. Mulch:
 - 1) Control by mulching is an integral part of the landscape programme and all mulches must be kept up to specification.
3. Removal of Shoots and Dead Twigs:
 - a. Remove any dead twigs or shoots occurring on all trees, shrubs and ground cover plants.
 - b. Remove all water shoots.
- H. Replacements:
 1. Replacement plants shall be of the same size (girth and height) and species as originally specified, and shall be planted as specified and shown on drawings.
 2. The Contractor shall be responsible for replacing all plant material that is dead, dying or not in vigorous condition at the beginning of the planting season following practical completion. At this time a schedule shall be prepared by the Contractor of all dead and dying material. This shall be submitted for approval to the Engineer.
 3. Replacements, with the exception of palm trees, shall be planted only between the start of November and the end of March. If the final inspection at the end of the maintenance period occurs between these dates and additional replacement planting is directed by the Engineer, the planting shall be done between mid and the end of October, and be maintained six months from November.
- I. Cleanup and Protection:
 1. During planting, keep pavements clean and work area in an orderly condition.



2. Protect planting and materials from damage due to landscape operations, operations by other contractors and trades and trespassers. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged planting as directed.
- J. Final Planting Inspection and Acceptance:
1. Final inspection for acceptance shall be made at the conclusion of the period of maintenance and guarantee provided that all project improvements and corrective work has been completed. If improvements are not completed, maintenance shall be continued until completion of such work.
 2. Prior to being considered ready for inspection, Contractor shall have done a final weeding and raking of all planted areas, replenishing of all mulch where necessary, removing all debris, leaving the site in a clean orderly appearance.

PART 2 PRODUCTS

2.1 PLANTING - GENERAL

- A. Planting shall take place only before 10:00 O'clock and after 16:30 O'clock.
1. The normal planting season for trees, shrubs and herbaceous plants will be between November and March inclusive, except for date palms which will be planted in March or April. Alternative planting times may be allowed only with the approval of the Engineer.
 2. Before beginning planting complete all grading and ripping, finish paving, laying of services and other building work; ensure the irrigation system is in good working order and complete soiling of shrub, herbaceous and annual planting areas.
 3. Planting shall not be done in excessively windy conditions.
- B. Layout:
1. Lay out individual tree and shrub locations for multiple plantings by scaling from the landscape site plans and stake locations and outline areas. Make minor adjustments as may be requested.
 2. The Engineer reserves the right to approve the setting out of plants before planting: see planting schedule and setting out drawings. He also reserves the right to alter the position of any which is planted.
 3. Space ground covers and vines as shown on schedule and drawings.
 4. The Engineer is to be notified 3 days minimum for the planting layout to be approved prior to planting.
- C. Planting is to be carried out in accordance with the specification and drawings. The number of each species and variety is to be distributed over the area allocated in an even manner, making due allowance for adjacent groups.
- D. Plants shall be set plumb and at such a level or elevation that after the settlement they will bear same relation to level of surrounding ground as they bore to ground from which they were dug. All plants shall be planted on and in soil mix. The soil mix will be properly compacted before the placement of trees with a heavy root ball.



- E. Earthballed and Hessian covered plants shall have all cloth, ropes, etc., removed from tops of the earthballs but no cloth shall be pulled out from under the earthballs.
- F. Bare-rooted plants shall have their roots spread out in a natural position and prepared top soil shall be carefully placed under and among them to fill all voids. Any roots which are broken or frayed shall be cleanly cut off from the plant.
- G. Disturbance to the roof system or ball of earth shall be prevented in removing plants from containers. Can cutters shall be used on metal containers.
- H. Dig planning pits to sizes as specified allowing for the depth of gravel drainage layer and cart away excavated material ensuring no interference with irrigation lines; removal of soil to approved designated waste disposal site.
- I. Lay the anti-capillary liner where specified over gravel taking care that 150mm overlaps occur and that the hole for the stake is no larger than necessary.
- J. Spread 200 mm layer of planting soil mix over the bottom of the pit and firm by foot. Place the plant and fill around it with planting soil mix in layers of 200 mm each separately firmed until final soil level is reached. The area of the plant pit should then be firmed around so the plant is stable. Apply slow release fertilizer where specified, at the rate of 300 gm/tree, 100 gm/plant, and 35 gm/m² of grass.
- K. During and after planting, the plants shall be thoroughly watered in to eliminate air voids around the roots and watered regularly as required for the planting to become established.
- L. Apply a 50mm deep layer of stone mulch as specified to planting beds and tree pits, using barrows to avoid interference with irrigation lines. Depth of stone mulch to be 50mm only.
- M. Check all plants one week after planting for wind shake and loosening due to soil subsidence and firm and make good soil as necessary. Then check all plants at a maximum of two weekly intervals until the end of the maintenance period, making good as necessary.

2.2 TREE PLANTING

- A. Trees of all species and of size specified on plans shall be planted in locations shown. Trees shown on plans at spacing shall be accurately and evenly spaced in true lines.
- B. The tree pits for Standard Trees generally shall allow for a 1000 x 1000 x 1500 mm depth of growing medium unless otherwise shown, plus a 200 mm deep gravel drainage layer. Where such tree pits are located above rock, bore holes will be drilled by the main Contractor prior to planting to a depth of 1m.
- C. After planting, a tree stake shall be inserted into the tree pit with a minimum of one third below ground and two thirds above ground. The stake shall be located on the windward side of the tree. For balled-root trees and those grown-on and in containers, a crowbar or similar tool should be used to probe through the root system, to make a pilot hole, into which the stake can be driven with minimum disturbance. Care shall



be taken not to puncture the semi-permeable membrane. The tree shall be secured to the tree stake by two rubber tree ties.

- D. Apply slow release tablet fertilizer as specified herein.

2.3 PALM TREE PLANTING

- A. Large palms shall be planted during the period of optimum root growth from March to April unless otherwise agreed upon with the Engineer. All palms scheduled to be planted on the site shall be inspected in their original growing location before lifting is authorized for delivery to the site.
1. Prior to transporting for transplanting, palm fronds are to be sprayed with anti-desiccant during transplanting and shall be wrapped with burlap to enclose the growing tip and upper trunk. The roots shall be balled and the Hessian tied with wire.
 2. Palms shall be planted in prepared pits, size as specified, and backfilled and firmed in.
 3. Fertilizer shall be applied as for trees.
 4. Trunk burlap, frond wrapping and dead fronds to be removed again after new growth indicates adequate recovery or after second growing season.
 5. Guy palms immediately after planting.
 6. The tree pits for palms generally shall allow for a 1500 x 1500 x 2000 mm depth of growing medium unless otherwise indicated on the drawings plus a 200 mm deep gravel drainage layer.

2.4 SHRUB PLANTING

- A. Shrubs shall be positioned in the location and numbers shown on plan and placed to achieve even spacing and proper matching of shapes related in a random fashion at approximately equal centers to obtain a natural dense cover.
1. Pits for shrubs and small trees generally shall allow for a depth of 900mm of growing medium, unless otherwise shown, plus a 200 mm deep gravel drainage layer.
 2. Planting pits shall be backfilled with planting soil mix, thoroughly firmed around the roots to eliminate air voids.
 3. Tablets fertilizer shall be applied.

2.5 VINE PLANTING

- A. Vines shall be planted in a similar manner to shrubs, all as described above.
- B. Pits for vines shall allow for a 900 x 900 x 600 mm depth of growing medium plus a 200 mm deep gravel drainage layer.

2.6 GROUND COVER PLANTS

- A. Ground cover plants shall be planted in beds of growing medium 500 mm deep plus a 200 mm deep gravel drainage layer. Planting should be done with a hand trowel, taking care to firm soil around the roots.
- B. Herbaceous plants should be set out according to the planting plan to ensure correct spacing.



- C. Smaller plants and annuals should be planted with a hand trowel, taking care to firm around the roots. Larger plants will require a spade to excavate hole, and firming should be done by treading. The depths of planting will depend upon the species.

2.7 GRASS

- A. Previously established grades shall be on the areas to be treated in a true and even condition, and necessary repairs shall be made to previously graded areas. All surfaces shall be left in a smooth condition to prevent formation of depressions. Areas having inadequate drainage as indicated by the ponding of water near foundations, walks, driveways, or on other areas shall be filled or graded to drain as directed by the Engineer. Ruts, deep tracks, dead furrows, and ridges shall be eliminated and the necessary replanting accomplished prior to acceptance of the completed work. The finished grade shall be such that after sodding operations, the sodded grade will be level with the adjacent surface grade of walks, drives and curbs. All debris and stones larger than 25mm remaining on the surface after grading and tillage operations shall be removed.
- B. After the areas have been brought to the previously established grades, tillage shall be accomplished in such manner as to prepare an acceptable sod bed. Contractor shall utilize a tractor-mounted or walk behind root-tiller type machine capable of tilling the soil and incorporating the soil amendments to the specified depth. After completion of tillage, lawn areas shall be raked smooth and stone and debris removed.
- C. Prior to commencing tillage operation, Contractor shall spread organic matter to a uniform depth of 25mm. Organic matter shall then be incorporated into the top 15cm of the turf bed to establish a uniform planting soil consisting of 5 parts existing topsoil and 1 part organic matter.
- D. Prior to tillage for planting NPK fertilizer shall be applied at the rate of 560 kg per hectare. Fertilizer shall be distributed with a fertilizer distributor equipped with baffle plates to prevent downward movement of fertilizer when operated on a slope. Fertilizer shall be uniformly distributed.
- E. Installation of sod shall be done by experienced staff. Each sod-roll will be hand held till laid down; no sod-rolls shall be accepted when thrown to the ground from truck or wheel barrow. When rolls are laid out, they shall be “tucked in” close, no gaps (space) to be left between rows of sod. A “walk-behind” water-filled metal roller shall be utilized to press the sod firmly down on the soil, to the Engineer’s approval.
- F. The sodded areas shall be refertilized three weeks after commencement of maintenance operations and thereafter at four week intervals throughout the growing season. Fertilizer for refertilizing shall be applied at the rate of 280kg of 16-16-16 per hectare. Fertilizer shall be applied only when vegetation is dry. The refertilized areas shall be irrigated within 4 hours following refertilizing operation.
- G. Sodding shall not be done:
 - 1. when the ground is in an unsatisfactory condition for planting or when the sod is not acceptable to Engineer;
 - 2. In Winter: when soil is too wet, or too cold, top 10cm of soil should not be less than 20°C.



3. In Summer: when soil is too dry; no installation of sod between 10 am and 3 pm unless approved by Engineer, in both cases, Engineer's approval to commence is required.
- H. Sod shall be installed as soon as possible after delivery to site.
- I. Sod shall be transported during night time, up to 8 am, or late afternoon after 5 pm.
- J. All sod shall be inspected and approved by Engineer before unloading. It is the Contractors responsibility if the sod is inspected after unloading and rejected.
- K. Sod shall originate from approved regional sod farms and each load shall have a certificate of the approved sod farms indicating time of lifting and loading and the type of grass (e.g. Cynadon & Variety).
- L. Irrigation shall commence within 2 to 4 hours of completing sodding planting. The irrigation system installed on the site shall be used; however any failure of this system does not eliminate the Contractor's responsibility of maintaining the desired level of moisture necessary to promote establishment of the grass. In the event of irrigation system failure, irrigation water shall be applied using portable rotating sprinklers. Irrigation water shall be applied as necessary to maintain the top 4 inches (10cm) of soil in a moist condition. Irrigation shall be accomplished in a manner that will not create erosion or runoff. All areas damaged shall be repaired immediately at no cost to the Owner.
- M. After the sod is installed, irrigation shall be applied daily to maintain soil moisture between 100 percent and 70 percent of field capacity. Irrigation shall be applied in early morning or evening to enable the soil to absorb a maximum of water with minimum evaporation. The Contractor shall continue to irrigate and maintain the turf during the Establishment Period, until final acceptance.

2.8 SOIL MATERIALS

- A. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; minimum pH value of 5.4 and maximum 7.0; organic matter to exceed 1.5%, magnesium to exceed 100 units; phosphorus to exceed 150 units; potassium to exceed 120 units; soluble salts/conductivity not to exceed 900 ppm/0.9 mmhos/cm in soil.

2.9 SOIL AMENDMENT MATERIALS

- A. When soil tests indicate soil amendment, apply soil conditioners or fertilizers to amend soil to specified conditions.
 1. Tree Fertilizer: Containing fifty percent of elements derived from organic sources; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis.
- B. Peat Moss: Shredded, loose, sphagnum moss; free of lumps, roots, inorganic material or acidic materials; minimum of 85 percent organic material measured by oven dry weight, pH range of 4 to 5; moisture content of 30 percent.



- C. Bone Meal: Raw, finely ground, commercial grade, minimum of 3 percent nitrogen and 20 percent phosphorous.
- D. Lime: Ground limestone, dolomite type, minimum 95 percent carbonates.
- E. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of plants.
- F. Herbicide: As instructed by the supplier.
- G. Pesticide: As instructed by the supplier.

2.10 MULCH MATERIALS

- A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

2.11 ACCESSORIES

- A. Wrapping Materials: Burlap.
- B. Stakes: Softwood lumber, pointed end, or mild steel angle, galvanized, pointed end.
- C. Cable, Wire, Eye Bolts and Turnbuckles: Non-corrosive, of sufficient strength to withstand wind pressure and resulting movement of plant life.
- D. Plant Protectors: Rubber sleeves over cable to protect plant stems, trunks, and branches.
- E. Plant Pot: As indicated on drawings.
- F. Grates: As indicated on drawings.
- G. Decorative Cover: As indicated on drawings.
- H. Membrane: 0.5 mm thick, clear or black polyethylene, and/or water permeable polyolefin fabric.
- I. Wrapping: Waterproof fabric.
- J. Tree Protectors: Metal or Plastic with galvanized rings.

2.12 TOPSOIL AND/OR PLANT SOIL MIX

- A. Topsoil and/or Plant Soil Mix: Uniform mixture of 1 part peat and 3 parts topsoil by volume.

2.13 SEPARATORS

- A. Junction between Different Types of Softscaping: Flexible PVC/rubber, 5 mm thick, width to cover the full depth of topsoil.



- B. Junction between Hardscaping and Softscaping: Flexible PVC/rubber with aluminum facing on both sides, 3.2 mm thick, width to cover the full depth of topsoil.

2.14 SOURCE QUALITY CONTROL

- A. General Requirements: Quality requirements for testing, inspection and analysis.
- B. Test and analyze imported and existing topsoil.
- C. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt and organic matter; and pH value.
- D. Provide recommendation for fertilizer and soil amendment application rates for specified planting as result of testing.
- E. Testing is not required when recent tests are available for imported topsoil. Submit these test results to testing laboratory. Indicate, by test results, information necessary to determine suitability.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify prepared subsoil and planters are ready to receive work.
- C. Saturate soil with water to test drainage.
- D. Verify required underground utilities are available, in proper location, and ready for use.

3.2 PREPARATION OF SUBSOIL

- A. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
- B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated subsoil.
- C. Scarify subsoil to depth of 75 mm where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.
- D. Dig pits and beds three times wider than plant root system.

3.3 EXCAVATION

- A. Excavate for tree and shrub plantation, and for ground cover as per Section 02315.



3.4 PLACING DRAINAGE LAYER

- A. Fill and spread gravel materials as a drainage layer at bottom of pits and under ground cover to required thickness.
- B. Place geotextile on top of drainage layer.

3.5 PLACING TOPSOIL

- A. Spread topsoil to minimum depth of 150 mm over area to be planted. Rake smooth.
- B. Place topsoil during dry weather and on dry subgrade.
- C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.
- D. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.
- E. Install topsoil into pits and beds intended for plant root balls, to minimum thickness of 150 mm.

3.6 FERTILIZING

- A. Apply starter fertilizer at rate instructed by supplier.
- B. Apply after initial raking of topsoil.
- C. Mix thoroughly into upper 50 mm of topsoil.
- D. Lightly water soil to aid dissipation of fertilizer.

3.7 PLANTING

- A. Place plants for best appearance for review and final orientation by the Engineer.
- B. Set plants vertical.
- C. Remove non-biodegradable root containers.
- D. Set plants in pits or beds, partly filled with prepared plant mix, at minimum depth of 150 mm unless otherwise indicated on Drawings under each plant. Remove loosen burlap, ropes and wires from top half of root ball.
- E. Place bare root plant materials so roots lie in natural position. Backfill soil mixture in 150 mm layers. Maintain plant life in vertical position.
- F. Saturate soil with water when pit or bed is half full of topsoil and again when full.

3.8 PLANT RELOCATION AND RE-PLANTING

- A. Relocate plants as indicated on drawings and/or directed by the Engineer.



- B. Ball or pot removed plants when temporary relocation is required.
- C. Replant plants in pits or beds, partly filled with prepared topsoil mixture, at minimum depth of 150 mm unless otherwise indicated on Drawings under each plant. Remove and loosen burlap, ropes, and wires, from top half of root ball.
- D. Place bare root plant materials so roots lie in natural position. Backfill soil mixture in 150 mm layers. Maintain plant materials in vertical position.
- E. Saturate soil with water when pit or bed is half full of topsoil and again when full.

3.9 INSTALLATION OF ACCESSORIES

- A. Place decorative cover, membrane, gravel, or stone as indicated on Drawings.
- B. Place grates with frames and reinforced concrete border support, at base of trees where indicated on Drawings.
- C. Wrap deciduous shade and flowering tree trunks and place tree protectors.

3.10 PLANT SUPPORT

- A. Brace plants vertically with plant protector wrapped guy wires and stakes to the following:

<u>Tree Caliper</u>	<u>Tree Support Method</u>
25 mm	1 stake with one tie
25 - 50 mm	2 stakes with two ties
50 - 100 mm	3 guy wires with eye bolts and turn buckles
Over 100 mm	4 guy wires with eye bolts and turn buckles

3.11 TREE PRUNING

- A. When pruning trees is required and permitted, lightly prune trees in accordance with ANSI A300 Maintenance Pruning Type: Crown Cleaning.

3.12 SEPARATORS

- A. Install separators at junction between different types of softscaping, and at junction between hardscaping and softscaping.

3.13 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Plants will be rejected when ball of earth surrounding roots has been disturbed or damaged prior to or during planting.



3.14 PROTECTION

- A. Immediately after planting, the area shall be protected against traffic and others by erecting barricades, as required, and placing approved signs at appropriate intervals until final acceptance.
- B. Excess and waste material shall be removed daily to approved waste disposal site. When planting in an area has been completed, the area shall be cleaned of all debris and excess materials. Adjacent paving shall be cleaned when work in adjacent areas is completed.

3.15 SCHEDULES - PLANT LIST

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 03100

CONCRETE FORMS AND ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Formwork for cast-in place concrete.
 - 2. Shoring, bracing, and anchorage.
 - 3. Architectural form liners.
 - 4. Form accessories.
 - 5. Form stripping.
- B. Related Sections:
 - 1. Section 03200 - Concrete Reinforcement.
 - 2. Section 03300 - Cast-in-Place Concrete.

1.2 REFERENCES

- A. American Concrete Institute:
 - 1. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
 - 2. ACI 301 - Specifications for Structural Concrete.
 - 3. ACI 318M - Metric Building Code Requirements for Structural Concrete.
 - 4. ACI 347 - Guide to Formwork for Concrete.
- B. American Forest and Paper Association:
 - 1. AF&PA - National Design Specifications for Wood Construction.
- C. The Engineered Wood Association:
 - 1. APA/EWA PS 1 - Voluntary Product Standard for Construction and Industrial Plywood.
- D. American Society of Mechanical Engineers:
 - 1. ASME A17.1 - Safety Code for Elevators and Escalators.
- E. ASTM International:
 - 1. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
- F. West Coast Lumber Inspection Bureau:
 - 1. WCLIB - Standard Grading Rules for West Coast Lumber.

1.3 DESIGN REQUIREMENTS

- A. Design, engineer and construct formwork, shoring and bracing to conform to design and code requirements to achieve concrete shape, line and dimension as indicated on Drawings.



1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings:
 - 1. Submit formwork and shoring shop drawings.
 - 2. Indicate the following:
 - a. Pertinent dimensions, openings, methods of construction, types of connections, materials, joint arrangement and details, ties and shores, location of framing, studding and bracing, and temporary supports.
 - b. Means of leakage prevention for concrete exposed to view in finished construction.
 - c. Sequence and timing of erection and stripping assumed compressive strength at time of stripping, height of lift and height of drop during placement.
 - d. Vertical, horizontal and special loads in accordance with ACI 347, Section 2.2 and camber diagrams, when applicable.
 - e. Notes to formwork erector showing size and location of conduits and piping embedded in concrete in accordance with ACI 318M , Section 6.3.
- C. Product Data: Submit data on void form materials and installation requirements.
- D. Design Data: Indicate design data for formwork and shoring. Include structural calculations to support design.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with ACI 347, ACI 301 and ACI 318M.
- B. For wood products furnished for work of this Section, comply with AF & PA.
- C. Perform Work in accordance with the drawings and to the approval of the Engineer,
- D. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Design formwork under direct supervision of Professional Engineer experienced in design of this Work and approved by the Engineer.

1.7 MOCK-UP

- A. General Requirements: Quality requirements for mockup.
- B. Construct formwork for concrete mockups required in Section 03300, including formwork, form liners and form accessories.
- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.



1.8 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for storage and handling.
- B. Deliver void forms and installation instructions in manufacturer's packaging.
- C. Store off ground in ventilated and protected manner to prevent deterioration from moisture.

1.9 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate this Section with other sections of work, requiring attachment of components to formwork.

PART 2 PRODUCTS

2.1 WOOD FORM MATERIALS

- A. Plywood: Sound undamaged sheets with clean, true edges.
- B. Lumber Forms:
 - 1. Application: Use for edge forms and unexposed finish concrete.
 - 2. Boards: 150 or 200 mm wide, tongue and groove where explicitly shown on drawings, “Standard” Grade Douglas Fir, conforming to WCLIB Standard Grading Rules for West Coast Lumber. Surface boards on four sides.
- C. Plywood Forms:
 - 1. Application: Use for exposed fairfaced finish concrete.
 - 2. Forms: Conform to PS 1; full size 1200 x 2400 mm panels; each panel labeled with grade trademark of APA/EWA.
 - 3. Plywood for Surfaces to Receive Waterproofing Membrane: Minimum 18mm thick; APA/EWA “B-B Plyform Structural I Exterior” grade.
 - 4. Plywood where “Smooth Finish” is required, as indicated on Drawings: APA/EWA “HD Overlay Plyform Structural I Exterior” grade, minimum of 18 mm thick.

2.2 PREFABRICATED FORMS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Preformed Steel Forms: Minimum 1.5 mm matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished surfaces.
- C. Glass Fiber Fabric Reinforced Plastic Forms: Matched, tight fitting, stiffened to support weight of concrete without deflection detrimental to tolerances and appearance of finished concrete surfaces.



- D. Pan Type: Steel or Glass fiber of size and profile required.
- E. Tubular Column Type: Round; spirally wound laminated fiber, wood or glass fiber material; surface treated with release agent, non-reusable, sizes as indicated on Drawings.
- F. Void Forms: Moisture resistant treated paper faces, biodegradable, structurally sufficient to support weight of wet concrete mix until initial set; thickness as indicated on drawings.
- G. Steel Forms: Sheet steel, suitably reinforced, and designed for particular use indicated on Drawings.
- H. Form Liners: Smooth, durable, grainless and non-staining hardboard, unless otherwise indicated on Drawings.
- I. Framing, Studding and Bracing: Stud or No. 3 structural light framing grade.

2.3 ARCHITECTURAL FORM LINERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Architectural Form Liners: Polystyrene, acrylonitrile butadiene styrene (ABS), or polyurethane; reusable; pattern as indicated on Drawings and/or as selected.

2.4 FORMWORK ACCESSORIES

- A. Form Ties: Removable or Snap-off type, galvanized metal, adjustable length, cone type, with waterproofing washer, free of defects capable of leaving holes larger than 25 mm in concrete surface.
- B. Spreaders: Standard, non-corrosive metal form clamp assembly, of type acting as spreaders and leaving no metal within 25 mm of concrete face. Wire ties, wood spreaders or through bolts are not permitted.
- C. Form Anchors and Hangers:
 - 1. Do not use anchors and hangers exposed concrete leaving exposed metal at concrete surface.
 - 2. Symmetrically arrange hangers supporting forms from structural steel members to minimize twisting or rotation of member.
 - 3. Penetration of structural steel members is not permitted.
- D. Form Release Agent: Colorless mineral oil that will not stain concrete, or absorb moisture, or impair natural bonding or color characteristics of coating intended for use on concrete.
 - 1. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- E. Corners: Chamfer, rigid plastic or wood strip type; size as directed by the Engineer; maximum possible lengths.



- F. Dovetail Anchor Slot: Galvanized steel, 0.8 mm thick, foam filled or non-filled, release tape sealed slots, anchors for securing to concrete formwork.
- G. Flashing Reglets: Galvanized steel, 0.8 mm thick, longest possible lengths, with alignment splines for joints, foam filled or non-filled, release tape sealed slots, anchors for securing to concrete formwork.
- H. Vapor Retarder: Where indicated on Drawings, 0.25 or 0.30 mm thick polyethylene sheet.
- I. Bituminous Joint Filler: ASTM D1751.
- J. Nails, Spikes, Lag Bolts, through Bolts, Anchorages: Size, strength and character to maintain formwork in place while placing concrete.
- K. Water Stops: Polyvinyl chloride, minimum 12 MPa tensile strength, minimum +10 °C to +79 °C working temperature range, width as indicated on drawings but not less than 250 mm wide, maximum possible lengths, ribbed profile, preformed corner sections, heat welded jointing.
- L. Expanding Type Water Stops (Water Bars): Flexible; swellable; expandable; forming into the joint and filling all cavities; resistant to water up to 5 bar; high chemical resistant (Type C); minimum +10 °C to +40 °C working temperature range; size 25x20 mm or 20x10 mm as directed by the Engineer and/or as indicated on drawings, maximum possible lengths.
- M. Anti-Termite Barrier: In accordance with the standards of relevant local authorities having jurisdiction and/or Municipality.
- N. Protection Boards to Vertical Surface of Anti-Termite Barrier: Polypropylene protection boards, 2 mm thick, 330 g/m², Cartonplast or similar approved.

2.5 COATINGS

- A. Coatings for Aluminum: Polyamide epoxy finish coat with paint manufacturer's recommended primer for aluminum substrate. Apply one coat primer and one coat finish.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify lines, levels, and centers before proceeding with formwork. Verify dimensions agree with Drawings.
- C. Verify concrete cover over reinforcement is as shown on drawings.



3.2 INSTALLATION

- A. Earth Forms:
 - 1. Earth forms are not permitted.
- B. Formwork - General:
 - 1. Provide top form for sloped surfaces steeper than 1.5 horizontal to 1 vertical to hold shape of concrete during placement, unless it can be demonstrated that top forms can be omitted.
 - 2. Construct forms to correct shape and dimensions, mortar-tight, braced, and of sufficient strength to maintain shape and position under imposed loads from construction operations.
 - 3. Camber forms where necessary to produce level finished soffits unless otherwise shown on Drawings.
 - 4. Carefully verify horizontal and vertical positions of forms. Correct misaligned or misplaced forms before placing concrete.
 - 5. Complete wedging and bracing before placing concrete.
- C. Forms for Smooth Finish Concrete:
 - 1. Use steel, plywood or lined board forms.
 - 2. Use clean and smooth plywood and form liners, uniform in size, and free from surface and edge damage capable of affecting resulting concrete finish.
 - 3. Install form lining with close-fitting square joints between separate sheets without springing into place.
 - 4. Use full size sheets of form lines and plywood wherever possible.
 - 5. Tape joints to prevent protrusions in concrete.
 - 6. Use care in forming and stripping wood forms to protect corners and edges.
 - 7. Level and continue horizontal joints.
 - 8. Keep wood forms wet until stripped.
- D. Architectural Form Liners:
 - 1. Erect architectural side of formwork first.
 - 2. Attach form liner to forms before installing form ties.
 - 3. Install form liners square, with joints and pattern aligned.
 - 4. Seal form liner joints to prevent grout leaks.
 - 5. Dress joints and edges to match form liner pattern and texture.
- E. Forms for Surfaces to Receive Membrane Waterproofing: Use plywood or steel forms. After erection of forms, tape form joints to prevent protrusions in concrete.
- F. Framing, Studding and Bracing:
 - 1. Space studs at 400 mm on center maximum for boards and 300 mm on center maximum for plywood.
 - 2. Size framing, bracing, centering, and supporting members with sufficient strength to maintain shape and position under imposed loads from construction operations.
 - 3. Construct beam soffits of material minimum of 50 mm thick.
 - 4. Distribute bracing loads over base area on which bracing is erected.
 - 5. When placed on ground, protect against undermining, settlement or accidental impact.



- G. Erect formwork, shoring, and bracing to achieve design requirements, in accordance with requirements of ACI 301.
- H. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.
- I. Obtain Engineer's approval before framing openings in structural members not indicated on Drawings.
- J. Chamfer strips on external corners of beams, joists, columns and etc.
- K. Install void forms in accordance with manufacturer's recommendations.
- L. Reuse formwork after approval of the Engineer. Do not patch formwork.

3.3 APPLICATION - FORM RELEASE AGENT

- A. Apply form release agent on formwork in accordance with manufacturer's recommendations.
- B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.
- C. Do not apply form release agent where concrete surfaces are indicated to receive special finishes or applied coverings that are affected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.
- D. Reuse and Coating of Forms: Thoroughly clean forms and reapply form coating before each reuse. For exposed work, do not reuse forms with damaged faces or edges. Apply form coating to forms in accordance with manufacturer's specifications. Do not coat forms for concrete indicated to receive "scored finish". Apply form coatings before placing reinforcing steel.

3.4 INSTALLATION - INSERTS, EMBEDDED PARTS AND OPENINGS

- A. Install formed openings for items to be embedded or passing through concrete work.
- B. Locate and set in place items required to be cast directly into concrete.
- C. Coordinate with Work of other sections in forming and placing openings, slots, reglets, recesses, sleeves, bolts, anchors, other inserts, and components of other Work.
- D. Position recessed reglets for brick veneer masonry anchors in accordance with spacing and intervals indicated on approved Shop Drawings.
- E. Install accessories straight, level, and plumb. Ensure items are not disturbed during concrete placement.
- F. Install water stops continuous without displacing reinforcement and in accordance with manufacturer's instructions.



- G. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.
- H. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.
- I. Form Ties:
 - 1. Use sufficient strength and sufficient quantity to prevent spreading of forms.
 - 2. Place ties at least 25 mm away from finished surface of concrete.
 - 3. Leave inner rods in concrete when forms are stripped.
 - 4. Space form ties equidistant, symmetrical and aligned vertically and horizontally unless otherwise shown on Drawings.
- J. Arrangement: Arrange formwork to allow proper erection sequence and to permit form removal without damage to concrete.
- K. Construction Joints:
 - 1. Install surfaced pouring strip where construction joints intersect exposed surfaces to provide straight line at joints.
 - 2. Just prior to subsequent concrete placement, remove strip and tighten forms to conceal shrinkage.
 - 3. Show no overlapping of construction joints. Construct joints to present same appearance as butted plywood joints.
 - 4. Arrange joints in continuous line straight, true and sharp.
- L. Embedded Items:
 - 1. Make provisions for pipes, sleeves, anchors, inserts, reglets, anchor slots, nailers, water stops, and other features.
 - 2. Do not embed wood or uncoated aluminum in concrete.
 - 3. Obtain installation and setting information for embedded items furnished under other Specification sections.
 - 4. Securely anchor embedded items in correct location and alignment prior to placing concrete.
 - 5. Verify conduits and pipes, including those made of coated aluminum, meet requirements of ACI 318M, Section 6.3.
- M. Openings for Items Passing through Concrete:
 - 1. Frame openings in concrete where indicated on Drawings. Establish exact locations, sizes, and other conditions required for openings and attachment of work specified under other sections.
 - 2. Coordinate work to avoid cutting and patching of concrete after placement.
 - 3. Perform cutting and repairing of concrete required as result of failure to provide required openings.
- N. Screeds:
 - 1. Set screeds and establish levels for tops of concrete slabs and levels for finish on slabs.
 - 2. Slope slabs to drain where required or as shown on Drawings.
 - 3. Before depositing concrete, remove debris from space to be occupied by concrete and thoroughly wet forms. Remove freestanding water.



- O. Screed Supports:
 - 1. For concrete over waterproof membranes and vapor barrier membranes, use cradle, pad or base type screed supports which will not puncture membrane.
 - 2. Staking through membrane is not permitted.
- P. Cleanouts and Access Panels:
 - 1. Provide removable cleanout sections or access panels at bottoms of forms to permit inspection and effective cleaning of dirt, debris and waste material.
 - 2. Clean forms and surfaces against which concrete is to be placed. Remove chips, saw dust and other debris. Thoroughly blow out forms with compressed air just before concrete is placed.

3.5 FORM CLEANING

- A. Clean forms as erection proceeds, to remove foreign matter within forms.
- B. Clean formed cavities of debris prior to placing concrete.
- C. Flush with water or use compressed air to remove remaining foreign matter. Ensure that water and debris drain to exterior through clean-out ports.
- D. During cold weather, do not use de-icing salts. Do not use water to clean out forms, unless formwork and concrete construction proceed within heated enclosure. Use compressed air or other means to remove foreign matter.

3.6 FORM REMOVAL

- A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads and removal has been approved by the Engineer.
- B. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.
- C. Store removed forms in manner that surfaces to be in contact with fresh concrete will not be damaged. Discard damaged forms.
- D. Leave forms in place for minimum number of days as specified in ACI 347.

3.7 ERECTION TOLERANCES

- A. Construct formwork to maintain tolerances required by ACI 301.
- B. Tolerances: Construct formwork to produce completed concrete surfaces within construction tolerances specified in ACI 117.
- C. Construct and align formwork for elevator hoistway in accordance with ASME A17.1.
- D. Camber slabs and beams 2 mm/m and in accordance with ACI 301.



3.8 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.
- C. Notify the Engineer after placement of reinforcing steel in forms, but prior to placing concrete.
- D. Schedule concrete placement to permit formwork inspection before placing concrete.

3.9 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Reinforcing bars.
 - 2. Welded wire fabric.
 - 3. Reinforcement accessories.
- B. Related Sections:
 - 1. Section 03100 - Concrete Forms and Accessories.
 - 2. Section 03300 - Cast-in-Place Concrete.
 - 3. Division 16 - Electrical: Grounding concrete reinforcement.

1.2 REFERENCES

- A. American Concrete Institute:
 - 1. ACI 301 - Specifications for Structural Concrete.
 - 2. ACI 315 - Details and Detailing of Concrete Reinforcement.
 - 3. ACI 318M - Metric Building Code Requirements for Structural Concrete.
 - 4. ACI SP-66 - ACI Detailing Manual.
- B. ASTM International:
 - 1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
 - 2. ASTM A184/A184M - Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.
 - 3. ASTM A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
 - 4. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 5. ASTM A641/A641M - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
 - 6. ASTM A704/A704M - Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement.
 - 7. ASTM A706/A706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
 - 8. ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
 - 9. ASTM A775/A775M - Standard Specification for Epoxy-Coated Reinforcing Steel Bars.
 - 10. ASTM A884/A884M - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement.
 - 11. ASTM A934/A934M - Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars.



12. ASTM A996/A996M - Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
 13. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
 14. ASTM D3963/D3963M - Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Reinforcing Steel Bars.
- C. American Welding Society:
1. AWS D1.4 - Structural Welding Code - Reinforcing Steel.
- D. Concrete Reinforcing Steel Institute:
1. CRSI - Manual of Standard Practice.
 2. CRSI - Placing Reinforcing Bars.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate bar sizes, spacings, locations, and quantities of reinforcing steel and welded wire fabric, bending and cutting schedules, and supporting and spacing devices.
- C. Certificates: Submit AWS qualification certificate for welders employed on the Work.
- D. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.
- E. Submit certified copies of mill test report of reinforcement materials analysis.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with CRSI - Manual of Standard Practice, ACI 301, ACI SP-66, and ACI 318M.
- B. Maintain one copy of each document on site.
- C. Arrange with access to fabrication plant to facilitate Engineer's inspection of reinforcement. Notify the Engineer of commencement and duration of shop fabrication in sufficient time to allow inspection.

1.5 QUALIFICATIONS

- A. Welders: AWS qualified within previous 12 months.

1.6 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate with placement of formwork, formed openings and other Work.



PART 2 PRODUCTS

2.1 REINFORCEMENT

- A. Reinforcing steel deformed bars shall conform to the requirements of the following:
 - 1. ASTM A706/A706M, Grade 60, 420 MPa minimum yield strength; deformed low-alloy steel bars, unfinished.
 - OR**
 - 2. ASTM A615/A615M, Grade 60, 420 MPa minimum yield grade; deformed steel bars, unfinished.
 - 3. Deformed reinforcing bars shall conform to one of the ASTM specifications listed above except that for bars with specified yield strength exceeding 420 MPa, the yield strength shall be taken as the stress corresponding to a strain of 0.35 percent.
 - 4. The values of reinforcement specified yield strength used in design calculations shall not exceed 550 MPa.
- B. Reinforcing Steel Plain Bar Stirrups and Rod Mats: ASTM A704/A704M, ASTM A615/A615M, 280 MPa; steel bars or rods, unfinished.
- C. Welded Steel Wire Fabric: To ASTM A497 Deformed Type.
- D. The weight of steel bar reinforcement for each bar diameter shall be in accordance with BS 4449: 1997: "Specification for Carbon Steel Bars for the Reinforcement".

2.2 ACCESSORY MATERIALS

- A. Tie Wire: Minimum 16 gage annealed type.
- B. Chairs, Bolsters, Bar Supports, Spacers: Sized and shaped for strength and support of reinforcement during concrete placement conditions including load bearing pad on bottom to prevent vapor retarder puncture.
- C. Special Chairs, Bolsters, Bar Supports, Spacers Adjacent to Weather Exposed Concrete Surfaces: Stainless steel type 316; size and shape to meet Project conditions.
- D. Reinforcing Splicing Devices: Mechanical set screw, swaged or threaded type; full tension and compression; sized to fit joined reinforcing.

2.3 FABRICATION

- A. Fabricate concrete reinforcement in accordance with CRSI Manual of Practice, ACI SP-66, ACI 318M, and/or ASTM A184/A184M.
- B. Weld reinforcement in accordance with AWS D1.4.
- C. Galvanized or Epoxy-Coated Reinforcement: Clean surfaces, weld and re-protect welded joint in accordance with CRSI.
- D. Locate reinforcement splices not indicated on Drawings, at point of minimum stress. Review location of splices with the Engineer.



PART 3 EXECUTION

3.1 PLACEMENT

- A. Place, support and secure reinforcement against displacement. Do not deviate from required position.
- B. Do not displace or damage vapor retarder.
- C. Accommodate placement of formed openings.
- D. Maintain concrete cover around reinforcement as indicated on drawings.
- E. Splice reinforcing where indicated on Drawings in accordance with splicing device manufacturer's instructions.
- F. Bond and ground reinforcement in accordance with requirements of Division 16.

3.2 REINFORCEMENT TESTS

- A. The manufacturer's test certificate for ultimate strength, elongation and cold bending together with the chemical analysis of the steel may be called for by the Engineer for any consignment or reinforcing steel direct from the manufacturer. Where steel is obtained from an indirect supplier, the Engineer may require tests in an approved laboratory to prove compliance with the appropriate American Standards.
- B. The frequency of testing shall be as set out in the American Standards. The Contractor shall carry out additional tests as instructed by the Engineer.
- C. Any reinforcement which does not comply with the Specification shall be immediately removed from site.

3.3 STORAGE OF MATERIALS

- A. Reinforcement of all types shall be stored on site in racks above ground in an approved manner so as to avoid damage.
- B. All reinforcement shall be free from loose scale, rust, oil, grease or any other material that may impair the bond between the concrete and the reinforcement. Any reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall be removed from site.
- C. Mild steel reinforcement shall be stored separately from high yield reinforcement.

3.4 CUTTING AND BENDING

- A. Reinforcement shall be bent to the dimensions given in the bar schedules in accordance with latest editions of ASTM A 184, ACI 318 CRSI 63 and CRSI 65 unless otherwise stated. The Contractor should check that schedules have been provided for each part of the structure.
- B. No reinforcement shall be heated before bending.



- C. Cold worked bars and hot rolled high yield bars shall not be straightened or bent again once having been bent. Where it is necessary to bend mild steel reinforcement already cast in the concrete, the internal radius of bend shall not be less than twice the diameter of the bar.
- D. After bending, bars shall be securely tied together in bundles or groups and legibly labeled as set out in CRSI 63 and CRSI 65.

3.5 SPLICING AND WELDING

- A. Reinforcement shall not be welded except where required by the Contract or agreed by the Engineer. If welding is employed the procedures shall be as set out in AWS D1.4. Details of all welding techniques to be used shall be submitted for approval and such trials made as are required to demonstrate the effect of the welding. No welding or splicing shall be made to the reinforcement except where described on the drawings, or where approved by the Engineer.

3.6 CLEANING OF REINFORCEMENT

- A. Reinforcement shall be free of all loose mill scale, rust, oil, grease, concrete or other harmful matter at the time of concreting.

3.7 FIXING OF REINFORCEMENT

- A. All reinforcement shall be accurately placed with the correct cover and securely fixed in the positions shown on the drawings and to the satisfaction of the Engineer, who shall be given reasonable notice of the intention to pour and that the reinforcement fixing is complete.
- B. At intersections the reinforcement bars shall be bound together with tying wire and the loose ends of the wire shall be turned towards the inside of the member.
- C. The Contractor shall supply and fix all chairs required to support the top mat of slab reinforcement or space the mats of all reinforcement adequately. In particular slab chairs must be close enough to prevent the reinforcement being bent or sagging.
- D. The actual concrete cover shall be not less than the required nominal cover minus 5mm. No metal part of any device used for connecting bars or for maintaining reinforcement in the correct position shall remain within the specified minimum cover. The Contractor shall provide adequate mortar or plastic spacers to ensure the correct cover is achieved. The use of spacer blocks will not generally be permitted against a concrete face which is to be permanently exposed in the finished works.

3.8 PROJECTING REINFORCEMENT

- A. The Contractor shall protect projecting reinforcement without affecting its bond properties and shall ensure that it does not cause rust staining to any part of the works.



3.9 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.

3.10 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes cast-in-place concrete for all concrete structures, frames, members, elements and beds shown on the drawings and where directed by the Engineer.
- B. Related Sections:
 - 1. Section 02320 - Backfill.
 - 2. Section 03100 - Concrete Forms and Accessories.
 - 3. Section 03200 - Concrete Reinforcement.
 - 4. Section 07130 - Sheet Waterproofing.
 - 5. Section 07140 - Fluid-Applied Waterproofing.
 - 6. Section 07900 - Joint Sealers.
 - 7. Division 15 - Mechanical: Mechanical items for casting into concrete.
 - 8. Division 16 - Electrical: Electrical items for casting into concrete.

1.2 REFERENCES

- A. American Concrete Institute:
 - 1. ACI 301 - Specifications for Structural Concrete.
 - 2. ACI 305 - Hot Weather Concreting.
 - 3. ACI 306.1 - Standard Specification for Cold Weather Concreting.
 - 4. ACI 318M - Metric Building Code Requirements for Structural Concrete.
- B. ASTM International:
 - 1. ASTM B221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric).
 - 2. ASTM C33 - Standard Specification for Concrete Aggregates.
 - 3. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
 - 4. ASTM C150 - Standard Specification for Portland Cement.
 - 5. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
 - 6. ASTM C330 - Standard Specification for Lightweight Aggregates for Structural Concrete.
 - 7. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.
 - 8. ASTM C595M - Standard Specification for Blended Hydraulic Cements (Metric).
 - 9. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
 - 10. ASTM C1017 - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
 - 11. ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).



12. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
13. ASTM D994 - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
14. ASTM D1190 - Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type.
15. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
16. ASTM D1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving & Structural Construction.
17. ASTM E1643 - Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs.
18. ASTM E1745 - Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Submit shop drawings showing proposed location of construction joints for Engineer's approval.
- C. Product Data: Submit data on joint devices, attachment accessories, and admixtures.
- D. Design Data:
 1. Submit concrete mix design for each concrete strength. Submit separate mix designs when admixtures are required for the following:
 - a. Hot and cold weather concrete work.
 - b. Air entrained concrete work.
 2. Identify mix ingredients and proportions, including admixtures.
- E. Samples: Submit two 250 x 250 mm long samples of expansion and contraction joints, and for control joint.
- F. Manufacturer's Installation Instructions: Submit installation procedures and interface required with adjacent Work.

1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.
- B. Project Record Documents: Accurately record actual locations of embedded utilities and components concealed from view in finished construction.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with ACI 301.
- B. Maintain one copy of each document on site.
- C. Acquire cement and aggregate from sources approved by the Engineer for Work.



- D. Conform to ACI 305 when concreting during hot weather.
- E. Conform to ACI 306.1 when concreting during cold weather.

1.6 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup for architectural concrete surfaces receiving special treatment or finish as result of formwork.
- C. Mockup Panel: Sufficient size to indicate special treatment or finish required.
- D. When requested by the Engineer, cast concrete against sample panel. Obtain acceptance of resultant surface finish prior to erecting formwork.
- E. Locate where directed by the Engineer.
- F. Remove mockup when directed by the Engineer.

1.7 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate placement of joint devices with erection of concrete formwork and placement of form accessories.

1.8 DELIVERY AND STORAGE OF AGGREGATES

- A. Aggregates shall be delivered to site in clean and suitable vehicles. Different types or sizes of aggregates shall not be delivered in one vehicle.
- B. Aggregates shall not be stored in contact with the ground and shall be protected against the intrusion of the ground and other foreign matter. There shall be a physical partition between the store heaps of fine and coarse aggregates and between separate heaped sizes of coarse aggregate which may have been segregated for mix control. When concreting is not being carried out, the store heaps shall be covered to prevent contamination by wind blown material.
- C. Aggregates, which in the opinion of the Engineer are not clean or which have become mixed due to defective storage, shall be removed from site immediately.

PART 2 PRODUCTS

2.1 CEMENT

- A. Cement shall comply with ASTM C150, Type I (ordinary Portland cement), Type II (moderate sulphate resisting cement), and/or Type V (sulphate resisting cement), all as indicated in the "Concrete Mix" stated below.



- B. White or colored cement shall comply with ASTM C150.
- C. The cement shall be obtained directly from an approved manufacturer or an approved supplier and shall be delivered either in bulk by purpose built vehicles or in sealed bags. All cement shall be free flowing and free of lumps.
- D. The total alkali content of the cement expressed as the sodium oxide equivalent shall not exceed 0.6% by weight.
- E. The tricalcium aluminates (C3A) content of ASTM C150 type I cement shall range from 7.5 to 11%, and for ASTM C150 type II and type V sulphate resisting cement shall not exceed 5%.
- F. The sulphuric anhydride (SO₃) content shall not exceed 2.3%.
- G. The heat of hydration shall not exceed values listed in ASTM C150.
- H. The initial setting time and the final setting time shall be as per ASTM C150.
- I. Certificates of cement tests by the manufacturer will be called for by the Engineer. If such certificate is not made available, or if the Engineer considers that the manufacturers tests are inadequate, samples for testing shall be taken from different consignments as the Engineer may direct. Such samples shall weigh not less than 7 kg and shall be selected and tested.
- J. Storage of Cement:
 - 1. Storage of bulk cement shall be in weatherproof silos which shall bear a clear indication of the types of cement contained in them. Different types of cement shall not be mixed in the same silo. Storage silos shall be drawn frequently to prevent cement caking.
 - 2. Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it. Each delivery of cement in bags shall be closely stacked but shall not be stacked against an outside wall. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stocks. Cement in bags shall be used in the order in which they are delivered. Cement from broken bags shall not be used in the Permanent Works.
 - 3. The Contractor shall provide sufficient storage capacity on site to ensure that his anticipated programme of work is not interrupted due to lack of cement.

2.2 AGGREGATES

- A. Aggregates for concrete shall conform to the requirements for fine and coarse aggregates in ASTM C33.
- B. Aggregates shall consist of crushed or naturally occurring materials having hard, durable, strong particles. All aggregates are to be washed with clean water. The use of marine aggregates will not be approved.



- C. At least 45 days before concreting operations are due to commence, the Contractor shall submit for approval the names of the pits, quarries or manufacturing plants from which he proposes to obtain aggregates, together with evidence showing that the material complies with the requirements of ACI 221.
- D. Fine aggregate shall either consist of natural sand or be obtained by crushing clean hard rock or be a mixture of these. Fine aggregate shall conform to ASTM C33 in order to achieve an acceptable grading it may be necessary to blend materials from more than one source.
- E. Fine aggregate shall contain no excessive quantities of dust, soft or flaky particles, shells, congealed lumps, shale or other contaminations likely to adversely affect the strength or durability of the concrete or to attack the reinforcement.
- F. Coarse aggregates shall consist of naturally occurring crushed rock and shall not contain harmful materials in sufficient quantity to affect adversely the strength or durability of the concrete or to attack the reinforcement.
- G. Coarse aggregates shall be supplied in the nominal sizes specified and shall be graded in accordance with ASTM C33 for single sized aggregates.
- H. In construction specified on drawings as watertight the coarse aggregates shall not have combined indices for flakiness and elongation exceeding 35, nor shall the flakiness index exceed 15.
- I. The sulphate content (SO_3) of both fine and coarse aggregates shall not exceed 0.4% by weight. The total sulphate content of all the ingredients in a mix including cement, water and admixtures shall not exceed 4.0% of the weight of cement within the mix.
- J. The chloride content (as NaCl) shall not exceed 0.05% by weight. The total chloride content arising from all ingredients in a mix including cement, water and admixtures shall not exceed the following limits expressed as a percentage of the weight of the cement in the mix:
 - 1. For prestressed concrete, steam cured concrete or concrete containing sulphate resisting cement: 0.05%.
 - 2. For any other reinforced concrete: 0.25% in 95% of all test results providing no result is more than 0.4%.
- K. The coarse aggregate, when tested, shall have water absorption as defined in ASTM C33. If the proposed aggregate has absorption of more than specified, the Contractor shall demonstrate by trial mixes and tests that the strength and durability of the concrete are not adversely affected and the adequate workability can be maintained during the placing and compacting processes.
- L. The “10% Fines” values shall be determined in accordance with ASTM C33. Where aggregates are to be used for concrete wearing surfaces, the “10% Fines” value shall be as specified in ASTM C33.
- M. After the magnesium sulphate soundness test, the weight loss shall not be more than 15% for the fine aggregate and 18% for the coarse aggregate.



- N. No part of the aggregates shall contain any mineral known to have a potential to cause alkali silica, alkali silicate, alkali carbonate or any other damaging chemical reactions between alkalis and aggregates.
- O. The grading of all aggregate, when analyzed, shall be as per ASTM C33 for the nominal size of aggregate specified.
- P. The Contractor shall carry out routine testing of aggregates for compliance with the specification during the period in which concrete is being produced for the Permanent Works. The routine tests include but are not limited to grading, silt and clay content, moisture content, check an organic impurities and chloride content. These tests shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to site provided that no set of tests shall represent more than 250 tones of coarse aggregate and provided also that the aggregates are of uniform quality.

2.3 WATER

- A. The water to be used in mixing concrete shall be clean and free from all harmful matter in suspension or solution and shall satisfy the recommendations given in ASTM C1602. If directed by the Engineer, the Contractor shall carry out tests in accordance with ASTM C1602 to establish compliance with the Specification.

2.4 ADMIXTURES

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Suitable chloride free admixtures may be used only with the prior written approval of the Engineer. Both the proposed dosage and method of use shall be submitted to the Engineer together with the following data:
 - 1. The typical dosage and detrimental effects of under-dosage and over-dosage.
 - 2. The chemical name(s) of the main active ingredient(s) in the admixtures.
 - 3. Whether or not the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage.
- C. Unless otherwise agreed on, admixtures shall comply with the following standards:
 - 1. ASTM C618 - Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
 - 2. ASTM C260 - Air-Entraining Admixtures for Concrete.
 - 3. ASTM C494 - Chemical Admixtures for Concrete
 - 4. ASTM C1240 - Amorphous Silica (Cementitious material other than Portland cement) Micro Silica. Limit percentage by weight in concrete to 7%.
 - 5. ASTM C1017 - Plasticizing

2.5 ACCESSORIES

- A. Bonding Agent: Two component modified epoxy resin bonding agent, mineral filled polysulfide polymer epoxy, unless otherwise indicated on drawings.



- B. Vapor Retarder: ASTM E1745; 0.25 mm thick clear polyethylene film; type recommended for below grade application. Furnish joint tape recommended by manufacturer.
- C. Non-Shrink Grout: ASTM C1107; premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 17 MPa in 48 hours and 48 MPa in 28 days.
- D. Concrete Reinforcing Fibers: ASTM C1116, high strength industrial-grade fibers specifically engineered for secondary reinforcement of concrete.
 - 1. Tensile Strength: 900 MPa.
 - 2. Toughness: 100 MPa.
 - 3. Fiber Length: 19 mm.
 - 4. Fiber Count: 34 million per 0.6 kg/m³.

2.6 PLASTIC SHEETING

- A. The plastic or polythene sheeting material for placing, where shown, immediately below concrete slabs, foundations, etc., and for other uses as defined elsewhere in the specification, shall be a film of 300 microns nominal thickness and a minimum thickness of 250 microns meeting the requirements of ASTM C171. The material shall be chemically inert and unaffected by subsoil acids and alkalis. The sheeting shall be stored out of the direct rays of the sun. All joints in the plastic sheeting shall be made with jointing tape and minimum laps shall be 300 mm.

2.7 WATERPROOFING MEMBRANE

- A. Where indicated on the drawings, waterproofing membrane to horizontal and vertical concrete surfaces below ground level shall conform to Section 07130.

2.8 WATERPROOFING PAINT

- A. Where indicated on the drawings, waterproofing paint to horizontal and vertical concrete surfaces below ground level shall conform to Section 07140.

2.9 WATERSTOPS

- A. Waterstops shall be in accordance with the requirements of Section 03100.

2.10 REJECTED MATERIALS

- A. All materials which have been damaged or are contaminated or unidentifiable or do not in all respects comply with the Specification shall be rejected and removed immediately from the site at the Contractor's expense.

2.11 TESTING LABORATORY AND EQUIPMENT

- A. The Contractor shall submit for approval the name of the Testing Authority he proposes to employ in accordance with the quality requirements for testing services of the Specifications General Requirements. He shall, in addition maintain at the site the following apparatus which shall be kept in good repair throughout the Contract:
 - 1. Apparatus for assessing workability.



2. Apparatus for making concrete cylinders as per ASTM C31 & ASTM C470.
3. A maximum and minimum thermometer to be kept on the Site close to the Works for measuring atmospheric shade temperature.
4. One soil thermometer and one concrete thermometer for measuring ground and concrete temperature in accordance with ASTM C1064.
5. A wet and dry bulb thermometer for measuring relative humidity.

2.12 TESTS

- A. All tests and checks carried out on site shall be in the presence of or as directed by the Engineer. The Contractor shall be responsible for carrying out all tests required by the Specification or called for by the Engineer. Unless otherwise specified the costs of all tests required are to be met by the Contractor whether the test results show the material or workmanship to be satisfactory for the work or not.
- B. If the Contractor proposes to adopt a designed concrete mix then he shall be responsible for carrying out the preliminary tests in accordance with this section of the Specification and send the results to the Engineer before placing any structural grade concrete made from the materials to be tested. No structural concrete shall be placed in the works until the relevant mix has been approved by the Engineer. The preliminary tests shall be carried out at the start of the contract on samples of the materials the Contractor intends to use on structural concrete grades. The preliminary tests shall be repeated whenever the Contractor proposes to change his source of supply and whenever in the opinion of the Engineer there was sufficient variation from the previously approved sample that new tests are required.

2.13 JOINT DEVICES AND FILLER MATERIALS

- A. Joint Filler: ASTM D1751 and/or ASTM D994; Asphalt impregnated fiberboard or felt, 6 mm thick; tongue and groove profile.
- B. Construction Joint Devices: Integral galvanized steel; formed to tongue and groove profile, knockout holes spaced at 150 mm, ribbed steel spikes with tongue to fit top screed edge.
- C. Expansion and Contraction Joint Devices: ASTM B221M, extruded aluminum; resilient elastomeric, vinyl or neoprene filler strip with Shore A hardness of 35 to permit plus or minus 25 percent joint movement with full recovery; extruded aluminum or vinyl cover plate, of longest manufactured length at each location, mounted as indicated on drawings; color as selected.
- D. Dowels: As specified in section 03200; diameter and length as shown on drawings.
- E. Waterstops shall conform to the requirements of Section 03100.
- F. Prefabricated Filling Materials: Celotex or similar approved; thickness as joint width.
- G. Fire Retardant Filler: Fireproof seals as per manufacturer's recommendations and of approved type.
- H. Backing Rod: As per manufacturer's recommendations and of approved type.



- I. Sealant and Primer: Type as specified in Section 07900.

2.14 CONCRETE MIX

- A. Mix and deliver concrete in accordance with ACI 301 and ASTM C94 respectively.
- B. Select proportions for normal weight concrete in accordance with ACI 301.
- C. Select aggregate proportions for lightweight concrete in accordance with ASTM C33, ACI 301 or ACI 318M.
- D. Prepare and submit Mix Design and Test Results of Mix Trials to the approval of the Engineer for the following different types/classes of concrete:

Structures and Beds	ASTM C150 Cement	Minimum Compressive Strength at 28 days on		Maximum Slump (± 20 mm) (mm)	Maximum Water to Cement Ratio	Minimum Cement Content (kg/m ³)	Notes
		cylinders (MPa)	cubes (MPa)				
Blinding.	Type I, II or V (as indicated)	14	18	180	0.60	250	Normal weight Mix.
Cyclopean concrete and reinforced concrete works.	Type I, II or V (as indicated)	30	38	180	0.42	350	Normal weight Mix.
Precast concrete works.	Type I, II or V (as indicated)	40	50	180	0.42	430	Normal weight Mix.

- E. All concrete exposed surfaces shall have a fairfaced finish at no additional cost.
- F. Concrete with only fine aggregate (less than or equal to 9 mm) may be used for highly reinforced elements or for elements with small thicknesses.
- G. Concrete slump of the different classes of concrete shall be measured to ASTM C143.
- H. Admixtures: Include admixture types and quantities indicated in concrete mix designs approved through submittal process.
1. Use accelerating admixtures in cold weather. Use of admixtures will not relax cold weather placement requirements.
 2. Use calcium chloride only when directed by the Engineer.
 3. Use set retarding admixtures during hot weather.
 4. Add air entraining agent to normal weight concrete mix for work exposed to exterior.
 5. Use water-reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete as required for workability.
 6. Use water-reducing admixture for concrete required to be watertight and concrete with a water-cement ratio below 0.50.
 7. Limit water-soluble chloride content in hardened concrete to 0.05 percent by weight of cement.

2.15 CYCLOPEAN CONCRETE

- A. Cyclopean concrete shall comprise 60% of the specified concrete and 40% "spalls" ranging in size from 100 to 250 mm.



- B. Stone and concrete shall be placed in alternate layers and in such a way that no stone shall be in contact with another or with shuttering sides. All faces of the cyclopean concrete shall show sound well compacted concrete.
- C. Spalls or boulders shall be free from sharp or angular edges, clean and free from dirt or earth, and soaked in water prior to incorporated into the concrete.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify requirements for concrete cover over reinforcement.
- C. Verify anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with placing concrete.

3.2 PREPARATION

- A. Clean with steel brush and apply bonding agent to previously placed concrete.
- B. In locations where new concrete is doweled to existing work, drill holes in existing concrete, air jet clean, insert steel dowels and pack solid with approved non-shrink grout.

3.3 QUALITY CONTROL OF CONCRETE PRODUCTION

- A. Three ready mix concrete suppliers shall be submitted for the Engineer one of which will be approved. The Contractor shall submit, for each proposed supplier, plant and mix results of full scale trial mixes. The average strength obtained in 28 days tests from these trials shall exceed the specified cylinder strength by at least the value given in 5.3.2.2 of ACI 318.
- B. The Contractor shall submit standard deviations for each supplier and plant, derived from results tested by an independent agency, on a recent construction project of similar size. All records shall be made available to the Engineer upon request.
- C. For each type/class of concrete in production at each plant for use in the Permanent Works, sample of concrete shall be taken at the point of discharge from the mixer or the ready mix delivery vehicle as instructed by the Engineer and in the presence of a representative of the Engineer, all in accordance with the sampling procedures described in ASTM C31. Slump test shall be carried out in accordance with the requirements of ASTM C143 whenever the Engineer may require it.
- D. Concrete cylinder shall be 150mm diameter. One sample shall be taken for every twenty cubic meters (20 m³) of each type/class of concrete placed with a minimum of one sample taken every day on which the mix is used. From each sample three cylinders shall be made, one for testing seven days after casting and two for testing 28



days after casting. The average strength of the two cylinders crushed at 28 days shall be referred to as one test result.

- E. Field cured samples shall be provided to ASTM C31 and as directed by Engineer.
- F. Concrete shall be deemed to comply with the strength specified if both of the following requirements are met:
 - 1. Every arithmetic average of any three consecutive strength tests equals or exceeds the average strength ($f'c$) at 28 days, and
 - 2. No individual strength test (average of two cylinders) falls below the specified average strength ($f'c$) at 28 days by more than 3.5 N/mm².
- G. If any strength test of laboratory-cured cylinders falls below specified value ($f'c$) by more than 3.5 N/mm² or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that load-carrying capacity of the structure is not jeopardized.
- H. If the likelihood of low-strength concrete is confirmed and calculations indicate that load-carrying capacity is significantly reduced, tests of cores drilled from the area in question in accordance with ASTM C42 shall be carried out. In such cases, three cores shall be taken for each strength test more than 3.5 N/mm² below the specified strength value of ($f'c$).
- I. If concrete in structure will be dry under service conditions, cores shall be air dried (temperature 15 to 25°C, relative humidity less than 60 %) for 7 days before test and shall be tested dry. If concrete in structure will be more than superficially wet under service conditions, cores shall be immersed in water for 40 hrs and be tested wet.
- J. Concrete in an area represented by core tests shall be considered structurally adequate if the average of three cores is equal to at least 85 percent of ($f'c$) and if no single core is less than 75 percent of ($f'c$). Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted.
- K. If the above criteria are not met and if the structural adequacy remains in doubt, the Engineer's decision for the appropriate action shall be followed.
- L. All cylinders shall be clearly marked with the date of casting and accurate records shall be supplied to the Engineer, stating the dates of taking and testing of samples, together with the results of tests and the exact position from which the sample was taken.

3.4 MIXING CONCRETE

- A. Unless otherwise agreed by the Engineer concrete shall be mixed in an approved type of mechanical weigh-batcher. No hand mixing will be allowed.
- B. The weighing and water-dispensing mechanisms shall be maintained in good order.
- C. The weights of cement and each size of aggregate as indicated by the mechanisms employed shall be within a tolerance of +/- 2 percent of the respective weights per batch agreed by the Engineer. The weight of the fine and coarse aggregates shall be adjusted to allow for the free water contained in the fine and coarse aggregates which



shall be determined by the Contractor by a method approved by the Engineer immediately before mixing begins, and further as the Engineer requires.

- D. The materials shall be mixed until they are uniformly distributed and the mass is of uniform consistency and color, but in no case shall the mixing time be less than two minutes after all the materials have been added to the drum. The drum on all mixers shall revolve at the speeds recommended by the manufacturer.
- E. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.
- F. Delivery notes with each batch delivered shall record the following:
 - 1. Date and time of arrival
 - 2. Time and place of mixing
 - 3. Registration of truck and depot
 - 4. Time and place of adding water
 - 5. Mix type/class
 - 6. Details of any approved additives

3.5 TRANSPORT AND PLACING OF CONCRETE

- A. The method of transporting and placing concrete shall be to the approval of the Engineer. Concrete shall be so transported and placed that contamination, segregation or loss of constituent materials does not occur.
- B. All formwork and reinforcement contained in it shall be clean and free from standing water immediately before the placing of the concrete.
- C. Concrete shall not be placed in any part of the structure until the Engineer's approval has been given.
- D. If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in situ concrete which has been in position for more than 30-minutes unless a construction joint is formed in accordance with this specification. When in situ concrete has been in place for 4 hours no further concrete shall be placed against it for a further 20 hours.
- E. Concrete when deposited shall have a temperature of not less than 5°C and not more than 28°C except with the approval of the Engineer.
- F. Except in the case of columns or where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 300 mm and each layer shall be well consolidated before the subsequent layer is placed.
- G. Except in the case of columns or unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 2 meters. When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation.



- H. Concrete shall not be pumped or discharge through aluminum or alloy conduits. Concreting shall be carried out continuously and no concrete shall be placed on concrete which has sufficiently set as to cause the formation of seams or planes of weakness with the section. Where concrete cannot be placed continuously, construction joints as specified shall be formed, only where shown on the drawings or approved by the Engineer.
- I. The time elapsing between mixing and placing a batch of concrete shall be as short as practicable. The time should be no longer than the duration that will permit completion of placing and compaction before the onset of initial set and in any case no longer than two hours from the time the water is added to the mix.

3.6 PLACEMENT OF CONCRETE IN LARGE SECTIONS

- A. The Contractor shall submit his proposals for the casting of the large concrete sections, where the minimum dimension is greater than 500mm, which shall include, but not limited to, proposed methods for controlling generated heat of hydration with supporting calculations, temperature monitoring and curing. Proposals shall comply with the recommendations of ACI 207.1, ACI 207.2, ACI 207.4, ACI 211.1 and ACI 224.3. All proposals shall be subject to the Engineer's approval.
- B. The temperature of the concrete in large sections shall be monitored through the section by the use of thermocouples. The Contractor shall ensure that the temperature of the concrete does not exceed 70°C and that any temperature differential (center to surface) across the section does not exceed 30°C. Temperature monitoring shall be continued until the temperature in the hottest part of the section is less than 20°C greater than the minimum daily ambient temperature, unless otherwise agreed with the Engineer.

3.7 INTERRUPTIONS TO PLACING

- A. If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already placed. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.
- B. Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.
- C. If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to a resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.



3.8 PUMPED CONCRETE

- A. If it is the Contractor's intention to transport concrete by pumping he is to obtain the Engineer's written approval at the commencement of the Contract. When submitting his proposals to the Engineer the Contractor must furnish the Engineer with full details of the mix design, the area and volume of concrete that he intends to place in an operation and the distance over which the concrete is to be pumped. The foregoing Clause on mix design will apply equally to a concrete that is designed to be "pumped".

3.9 PLACING CONCRETE - GENERAL

- A. Place concrete in accordance with ACI 301 and/or ACI 318M.
- B. Notify the Engineer minimum 24 hours prior to commencement of operations.
- C. Ensure reinforcement, inserts, embedded parts, and formed expansion and contraction joints are not disturbed during concrete placement.
- D. Install vapor retarder under interior slabs on grade in accordance with ASTM E1643. Lap joints minimum 150 mm and seal watertight by adhesive applied between overlapping edges and ends or by taping edges and ends.
- E. Repair vapor barrier damaged during placement of concrete reinforcing. Repair with vapor barrier material; lap over damaged areas minimum 150 mm and seal watertight.
- F. Separate slabs on grade from vertical surfaces with joint filler as instructed by the manufacturer.
- G. Place joint filler in floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
- H. Extend joint filler from bottom of slab to within 13 mm of finished slab surface. Conform to Section 07900 for finish joint sealer requirements.
- I. Install construction joint devices in coordination with floor slab pattern placement sequence. Set top to required elevations. Secure to resist movement by wet concrete.
- J. Install joint device anchors. Maintain correct position to allow joint cover to be flush with floor and wall finish.
- K. Install joint covers in longest practical length, when adjacent construction activity is complete.
- L. Apply sealants in joint devices in accordance with Section 07900.
- M. Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken.
- N. Place concrete continuously between predetermined expansion, control, and construction joints.



- O. Do not interrupt successive placement; do not permit cold joints to occur.
- P. Place floor slabs in pattern as indicated.
- Q. Saw cut joints within 12 hours after placing. Use 3/16 inch thick blade, cut into 1/4 depth of slab thickness.
- R. Screed floors level, maintaining surface flatness of maximum 6 mm in 3 m.

3.10 PLACEMENT OF CONCRETE UNDERWATER (IF REQUIRED)

- A. Underwater concreting shall be undertaken in accordance with BS 8004-2015: Code of Practice for Foundations.
- B. The Concrete mix shall have additional fine aggregate or filler materials to promote cohesion, all as recommended in BS 8004-2015: Code of Practice for Foundations.

3.11 SEPARATE FLOOR TOPPINGS

- A. Prior to placing floor topping where required, roughen substrate concrete surface and remove deleterious material. Broom and vacuum clean.
- B. Place required dividers and other items to be cast in.
- C. Apply sand and cement slurry coat on base course, immediately prior to placing toppings.
- D. Place concrete floor toppings to required lines and levels.
- E. Screed toppings level, maintaining surface flatness of maximum 3 mm /3 m.

3.12 COMPACTION OF CONCRETE

- A. All concrete shall be compacted to produce a dense homogeneous mass. Unless otherwise agreed and approved by the Engineer, it shall be compacted with the assistance of mechanical vibratory, and sufficient mechanical vibrators in serviceable condition shall be on site so that spare equipment is always available in the event of breakdown.
- B. Mechanical vibrators shall be of the immersion type capable of operating at between 7,000 and 10,000 cycles per minute.
- C. No vibrator shall be operated by a workman who has had insufficient training in its use.
- D. With immersion vibrators the tubular part of the tool shall be inserted vertically into the full depth of the concrete to be vibrated at points 600mm apart and at least 100mm away from any formwork. The vibrators shall be kept constantly moving whilst in action to prevent segregation. Vibration shall not be applied directly or through the formwork or reinforcement to sections or layers of concrete which have taken their initial set or to concrete which has ceased to become plastic under vibration. Vibration shall be stopped after the decrease in volume is no longer



apparent or before localized areas of grout or laitance are formed. Should the supply of concrete from the mixer be interrupted the vibrators should be lifted clear from the work.

- E. Care shall be taken to ensure that concrete is fully compacted around waterstops without distorting, displacing or damaging the waterstops.

3.13 CONCRETE FINISHING

- A. Provide formed concrete surfaces to be left exposed as indicated on drawings and/or as scheduled.
- B. Wood float surfaces receiving quarry tile, ceramic tile, and/or terrazzo with full bed setting system.
- C. Steel trowel surfaces receiving carpeting, resilient flooring, seamless flooring, thin set quarry tile, and/or thin set ceramic tile.
- D. Steel trowel surfaces that are indicated to be exposed.
- E. Power float surfaces which are indicated to be exposed and all surfaces which are directed by the Engineer:
 - 1. Consolidate surface with power driven floats as soon as topping can support equipment and operator.
 - 2. Re-straighten, cut down high spots, and fill low spots.
 - 3. Repeat float passes and re-straightening until surface is smooth and uniform in texture, and to the satisfaction of the Engineer.
- F. Brush or roll concrete surfaces shown on drawings, or directed by the Engineer:
 - 1. Apply first trowel finish.
 - 2. Apply a hardener type "carborandum" or similar approved on fresh poured concrete surfaces.
 - 3. Brush or roll concrete topping by appropriate tools when concrete surface is hard enough and as soon as topping can support equipment and operator.
 - a. Brushing ribs to be perpendicular to traffic, unless otherwise stated.
 - b. Rolling stamped pattern to be as shown on drawings or as directed by the Engineer.
- G. In areas with floor drains, maintain floor elevation at walls; pitch surfaces uniformly to drains as indicated on drawings.

3.14 PROTECTION OF FRESH CONCRETE

- A. Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from this cause.
- B. No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.
- C. Concrete placed in the Permanent Works shall not be subjected to any structural loading until it has attained at least its minimum average strength defined previously.



3.15 CURING AND PROTECTION

- A. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical injury.
- B. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.
- C. Cure concrete floor surfaces:
 - 1. Ponding: Maintain 100 percent coverage of water over floor slab areas continuously for 7 days.
 - 2. Spraying: Spray water over floor slab areas and maintain wet for 7 days.

3.16 CONCRETING IN HOT WEATHER

- A. On exposed concrete surface in high sun temperatures and/or strong drying wind conditions the Contractor shall use a curing method which also shields the concrete and this shall be placed in position no later than half an hour after final tamping. If the surface exhibits cracking while the concrete is still plastic then it shall be retamped to close the cracks.
- B. The Contractor shall plan the concreting days in such a manner as to ensure that each bay or panel is completed at a proper construction joint before the temperature rises above the permissible limit.
- C. The temperature of fresh mixed concrete at the point of placement shall not exceed 28°C and the Contractor should take all necessary precautions to ensure that the limit is not exceeded. Concrete with a temperature less than 28°C can be produced by combinations of the following methods:
 - 1. Use of sliced, flaked or crushed ice to reduce temperature of mixing water. All ice shall be melted before adding to concrete.
 - 2. Night casting (subject to the prior approval of the Engineer)
 - 3. Shading of aggregates
 - 4. Moistening of aggregates with potable water
 - 5. Cooling of formwork and reinforcement
 - 6. Using cement with a temperature of less than 77°C
 - 7. Use of white or light reflective paint on mixer drums and water storage tanks.
 - 8. Shading of the mixing area.

3.17 PROTECTION TO SUBSTRUCTURE

- A. Waterproofing membrane shall be provided where indicated on the drawings. Waterproofing membrane shall be installed in accordance with the requirements of Section 07130.
- B. Bituminous coating shall be applied with approved primer to concrete surfaces in contact with soil excluding surfaces receiving waterproofing membrane. Bituminous coating shall be applied in accordance with the requirements of Section 07140.
- C. Waterstops shall be installed in accordance with Section 03100.



- D. Except where indicated otherwise on the drawings or agreed by the Engineer, all buried concrete surfaces, exposed after the removal of formwork, shall be protected using a bituminous paint-on material. It shall consist of bitumen priming coat and a finishing coat of fiber reinforced bitumen. This membrane shall be applied before and in addition to the polythene sheet.

3.18 LIQUID CONTAINING CONSTRUCTION

- A. All liquid containing construction shall be tested to ensure no leakage or damp penetration. The testing shall be carried out before waterproofing backing or other finishes are applied to the construction and before back-filling any excavation.
- B. The Contractor shall seal completely all drains and fill the construction with clean water to a predetermined level. One filled the level is to be recorded at daily intervals for a period of fourteen days or as otherwise directed by the Engineer. Measures shall be taken by the Contractor to ensure that the level of water is not affected by rainfall or undue evaporation.
- C. Should it be apparent from the test results, external inspection or any other source that leakage/damp penetration has occurred, then, remedial work to make the construction completely watertight shall be carried out at the Contractor's expense and to the approval of the Engineer. Construction shall be retested until results are satisfactory.

3.19 PATCHING

- A. Allow the Engineer to inspect concrete surfaces immediately upon removal of forms.
- B. Excessive honeycomb or embedded debris in concrete is not acceptable. Notify the Engineer upon discovery.
- C. Patch imperfections in accordance with ACI 301.

3.20 DEFECTIVE WORK

- A. Any remedial treatment to surfaces shall be agreed with the Engineer following inspection immediately after removing the formwork, and shall be carried out without delay.
- B. Any concrete, the surface of which has been treated before being inspected by the Engineer, shall be liable for rejection.
- C. Any concrete which in the opinion of the Engineer is damaged or is in any way defective due to lack of compliance with any of the foregoing Clauses, or is not true to an acceptable line or level compatible with the requirements of second fixings and finishes, then this work will be deemed unacceptable and rejected.
- D. Where rejected work has to be cut out or re-built, the operation shall be carried out by the Contractor at his own expense and without delay.
- E. The extent of work to be removed and the methods to be used in the removal and replacement of work shall be proposed by the Contractor for the Engineer's approval.



- F. The Engineer's approval must be obtained before any cutting of concrete is carried out. If such cutting of concrete is carried out without the Engineers approval the affected areas shall be classified as defective. The Contractor is responsible for ensuring that a copy of this clause is given to each of his subcontractors, nominated or otherwise, and that they abide by it.
- G. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of the Engineer for each individual area.

3.21 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Field inspection and testing shall be performed in accordance with ACI 301 and under the provisions of the quality requirements of the Specifications General Requirements.
- C. Provide free access to Work and cooperate with appointed firm.
- D. Submit proposed mix design of each type/class of concrete to inspection and testing firm for review prior to commencement of Work.
- E. Tests of cement and aggregates may be performed to ensure conformance with specified requirements.
- F. One additional concrete test cylinder will be taken during cold weather concreting, cured on job site under same conditions as concrete it represents.
- G. One slump test will be taken for each set of concrete test cylinders taken.
- H. One air content test will be made for each set of concrete test cylinders taken.
- I. Maintain records of concrete placement. Record date, location, quantity, air temperature and test samples taken.
- J. Concrete cylinder strength tests can be replaced with standard concrete cube strength tests provided the number of cube tests and testing method and procedure is according to relevant codes and standards.

3.22 SCHEDULES

- A. Concrete Types and Finishes, and Joint Fillers: As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 03455

PLANT-PRECAST CONCRETE

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes precast concrete elements with supports, anchors and attachments.
- B. Related Sections:
 - 1. Section 03200 -Concrete Reinforcement.
 - 2. Section 03300 - Cast-in-Place Concrete.
 - 3. Section 05500 - Metal Fabrication.
 - 4. Section 07900 - Joint Sealers.

1.2 REFERENCES

- A. American Concrete Institute:
 - 1. ACI 301 - Specifications for Structural Concrete.
 - 2. ACI 318M - Metric Building Code Requirements for Structural Concrete.
- B. ASTM International:
 - 1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
 - 3. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
 - 4. ASTM A325M - Standard Specification for High-Strength Bolts for Structural Steel Joints (Metric).
 - 5. ASTM A416/A416M - Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
 - 6. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - 7. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 8. ASTM C33 - Standard Specification for Concrete Aggregates.
 - 9. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
 - 10. ASTM C150 - Standard Specification for Portland Cement.
 - 11. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
- C. American Welding Society:
 - 1. AWS D1.1 - Structural Welding Code - Steel.
 - 2. AWS D1.4 - Structural Welding Code - Reinforcing Steel.
- D. Precast/Prestressed Concrete Institute:
 - 1. PCI MNL-117 - Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products.
 - 2. PCI MNL-120 - PCI Design Handbook - Precast and Prestressed Concrete.



3. PCI MNL-122 - Architectural Precast Concrete.
4. PCI MNL-123 - Design and Typical Details of Connections for Precast and Prestressed Concrete.

1.3 DESIGN REQUIREMENTS

- A. Design units to withstand actual loads including water pressure, wave effect, deflection, and thermal movement loads.
- B. Design units to accommodate construction tolerances, and deflection of members.
- C. Design component connections to accommodate building movement and thermal movement. Provide adjustment to accommodate misalignment of structure without unit distortion or damage.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate layout, unit locations, configuration, reinforcement, connection details, support items, location of lifting devices, dimensions, openings, and relationship to adjacent materials.
- C. Design Data: Submit design data reports indicating calculations for loadings and stresses of fabricated, designed framing and connections.
- D. Samples: Submit two wall/parapet panels, 200 mm long x 200 mm wide x 20 mm thick in size illustrating surface finish, color and texture.

1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.
- B. Operation and Maintenance Data: Procedures for Project closeout submittals. Indicate surface cleaning instructions.

1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with PCI MNL-117, PCI MNL-120, PCI MNL-122, PCI MNL-123, or ACI 318M.
- B. Welding: AWS D1.1 and AWS D1.4.
- C. Perform Work in accordance with the drawings and to the satisfaction of the Engineer.
- D. Maintain one copy of each document on site.

1.7 QUALIFICATIONS

- A. Fabricator: Company specializing in performing Work of this section with minimum ten years documented experience.



- B. Design units under direct supervision of approved Professional Engineer experienced in design of this Work.

1.8 MOCK-UP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup panel, 2000 mm long by 400 mm wide by 1050 mm high, with lifting device, and attachment points, and finish in accordance with approved sample.
- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.

1.9 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. General Requirements: Product requirement for product storage and handling.
- B. Handle precast units to position, consistent with their shape and design. Lift and support only from support points.
- C. Blocking and Lateral Support during Transport and Storage: Clean, non-staining, without causing harm to exposed surfaces. Provide temporary lateral support to prevent bowing and warping.
- D. Protect units to prevent staining, chipping, or spalling of concrete.
- E. Mark units with date of production in location not visible to view when in final position in structure.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Furnish materials in accordance with the drawings and to the satisfaction of the Engineer.

2.2 MATERIALS

- A. Cement: In accordance with ACI 301 and as specified in Section 03300; air entrained 5% to 7%; color for facing mix as selected by the Engineer.



- B. Coarse and Fine Aggregate Materials: As specified in section 03300.
- C. Water: As specified in section 03300.
- D. Reinforcing Steel: As specified in section 03200.
- E. Air Entrainment Admixture: ASTM C260.
- F. Admixtures: As specified in section 03300.
- G. Surface Finish: As indicated on drawings and/or directed by the Engineer and conforming to approved submitted samples.
- H. Pigment or Coloring Agent: Of approved type, color as selected, resistant to alkalis.

2.3 FORM LINERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Material: Glass fiber reinforced polyester, acrylonitrile butadiene styrene, polyvinyl chloride, or polyurethane.

2.4 SUPPORT DEVICES

- A. Connecting and Support Devices: ASTM A36/A36M weldable or general construction steel.
- B. Bolts, Nuts, and Washers: ASTM A307 or ASTM A325M, high strength steel or high strength alloy steel.
- C. Primer: Zinc rich type.

2.5 ACCESSORIES

- A. Bearing Pads: High density plastic, steel, vulcanized elastomeric compound molded to size, neoprene (chloroprene, or tetrafluoroethylene) 3 mm thick, smooth both sides.
- B. Recessed Reglets: Galvanized steel, stainless steel, or plastic, shaped and flanged to remain in place once cast, foam plastic filled or taped closed to eliminate wet concrete intrusion.
- C. Sealant: Type specified in Section 07900.

2.6 FABRICATION

- A. Fabricate in conformance with PCI MNL-117.
- B. Maintain plant records and quality control program during production of precast units. Make records available upon request.



- C. Use rigid molds, constructed to maintain precast unit uniform in shape, size and finish.
- D. Utilize form liners.
- E. Maintain consistent quality during manufacture.
- F. Fabricate connecting devices, plates, angles, items fit to steel framing members, inserts, bolts, and accessories. Fabricate to permit initial placement and final attachment.
- G. Weld steel fabrications in accordance with AWS D1.1. Weld reinforcing steel in accordance with AWS D1.4. Do not tack weld reinforcing.
- H. Embed reinforcing steel, anchors, inserts plates, angles and other cast-in items.
- I. Cast rigid insulation into units if shown on the drawings.
- J. Place recessed flashing reglets continuous and straight.
- K. Locate hoisting devices to permit removal after erection.
- L. Cure units to develop concrete quality, and to minimize appearance blemishes including non-uniformity, staining, or surface cracking.

2.7 FINISH - PRECAST UNITS

- A. Finish Type A (To Match Adjacent Concrete Surface Finish): Ensure exposed-to-view finish surfaces of precast units are uniform in color and appearance.
- B. Finish Type B (Using Surface Retarder to Achieve Exposed Aggregate Finish): Remove cement mortar from areas affected by aggregate retarder.
- C. Finish Type C (Using Sandblasting to Produce Exposed Aggregate Finish): Sand blast exposed-to-view precast unit surfaces to light, medium or heavy exposure, as shown on the drawings and as directed by the Engineer. Protect adjacent surfaces.

2.8 FINISH - SUPPORT DEVICES

- A. Clean surfaces of rust, scale, grease and foreign matter.
- B. Prime paint in two coats, except surfaces in direct contact with concrete or requiring field welding.

2.9 FABRICATION TOLERANCES

- A. Maximum Out of Square: 1 mm/m, non-cumulative.
- B. Variation from Dimensions Indicated on Shop Drawings: Plus or minus 3 mm.
- C. Maximum Misalignment of Anchors, Inserts, Openings: 3 mm.



- D. Maximum Bowing of Units: Length of bow / 360.
- E. Location of Reglets: 6 mm from indicated position.

2.10 SOURCE QUALITY CONTROL AND TESTS

- A. General Requirements: Quality requirements for testing, inspection and analysis.
- B. Test and analyze concrete mix as specified in section 03300.
- C. Take concrete test cylinders as specified in section 03300.
- D. Take slump tests as specified in section 03300.
- E. Take one air entrainment test cylinders for each set of exterior concrete test cylinders taken.
- F. Take water absorption test in accordance with PCI MNL-117.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify building structure, anchors, devices and openings are ready to receive work of this Section.

3.2 PREPARATION

- A. Provide for erection procedures and induced loads during erection. Maintain temporary bracing in place until final support is provided.

3.3 ERECTION

- A. Erect units without damage to shape or finish. Replace or repair damaged panels.
- B. Erect units, level and plumb within allowable tolerances.
- C. Align and maintain uniform horizontal and vertical joints as erection progresses.
- D. When units require adjustment beyond design or tolerance criteria, discontinue affected work; advise the Engineer.
- E. Fasten and/or weld units in place. Perform welding in accordance with AWS D1.1.
- F. Touch-up field welds and scratched or damaged surfaces.
- G. Weld reinforcing steel in accordance with AWS D1.4. Do not tack weld reinforcing.



- H. Seal joints in accordance with Section 07900.

3.4 ERECTION TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation from Plane of Location: 2 mm in 3 m and 3 mm in 30 m, non-cumulative.
- C. Maximum Offset from Indicated Alignment between Two Connecting Units: 6 mm.
- D. Joint Tolerance: Plus or minus 6 mm.

3.5 ADJUSTING

- A. General Requirements: Execution requirements for testing, adjusting and balancing.
- B. Adjust units so joint dimensions are within tolerances.

3.6 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Use non-combustible shields during welding operations to protect adjacent Work.

3.7 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 05120

STRUCTURAL STEEL

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes structural steel framing members, support members, suspension cables, sag rods, and struts; base or bearing plates, shear stud connectors, and expansion joint plates; anchor bolts for structural steel; beams, girders, purlins, and girts; bearing of steel for girders, trusses or bridges; bracing; columns, posts; connecting materials for framing structural steel to structural steel; crane rails, splices, stops, bolts, and clamps; door frames constituting part of structural steel frame; expansion joints connected to structural steel frame; fasteners for connecting structural steel items; permanent shop bolts; shop bolts for shipment; field bolts for permanent connections; permanent pins; floor plates (checkered or plain) attached to structural steel frame; grillage beams and girders; hangers essential to structural steel frame; leveling plates, wedges, shims, and leveling screws; lintels, when attached to structural steel frame; trusses; and grouting under base plates.
- B. Related Sections:
 - 1. Section 04065 - Masonry Mortar and Grout.
 - 2. Section 05500 - Metal Fabrications.

1.2 REFERENCES (*Equivalent Equal Acceptable*)

- A. American Institute of Steel Construction:
 - 1. AISC S303 - Code of Standard Practice for Steel Buildings and Bridges.
- B. ASTM International:
 - 1. ASTM A6/A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
 - 2. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
 - 3. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 4. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 5. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 6. ASTM A242/A242M - Standard Specification for High-Strength Low-Alloy Structural Steel.
 - 7. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength.
 - 8. ASTM A325M - Standard Specification for High-Strength Bolts for Structural Steel Joints (Metric).
 - 9. ASTM A449 - Standard Specification for Quenched and Tempered Steel Bolts and Studs.
 - 10. ASTM A490M - Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric).



11. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 12. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 13. ASTM A514/A514M - Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding.
 14. ASTM A529/A529M - Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality.
 15. ASTM A563M - Standard Specification for Carbon and Alloy Steel Nuts (Metric).
 16. ASTM A568/A568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
 17. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
 18. ASTM A992 - Standard Specification for Steel for Structural Shapes.
- C. American Welding Society:
1. AWS A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 2. AWS D1.1 - Structural Welding Code - Steel.
- D. Research Council on Structural Connections:
1. RCSC - Specification for Structural Joints Using ASTM A325 or A490 Bolts.
- E. The Society for Protective Coatings (SSPC):
1. SSPC - Steel Structures Painting Manual.
 2. SSPC Paint 15 - Steel Joist Shop Paint.
 3. SSPC Paint 20 - Zinc-Rich Primers (Type I - Inorganic & Type II - Organic).
- F. Underwriters Laboratories Inc.:
1. UL - Fire Resistance Directory.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals procedures.
- B. Fabrication Drawings:
1. Indicate profiles, sizes, spacing, location of structural members, openings, attachments and fasteners.
 2. Design and details of connections.
 3. Cambers and loads.
 4. Indicate welded connections with AWS A2.4 symbols and net weld lengths.
- C. Mill Test Reports: Submit indicating structural strength, and destructive and non-destructive test analysis.
- D. Manufacturer's Mill Certificate: Certify products meet the specified requirements.
- E. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.



1.4 QUALITY ASSURANCE (*Equivalent Equal Acceptable*)

- A. Fabricate structural steel members in accordance with AISC S303.
- B. Perform Work in accordance with AISC S303, Section 10.
- C. Maintain one copy of each document on site.
- D. Fabricator: Company specializing in performing Work of this section with minimum twenty years documented experience and holding current AISC Certification.
- E. Erector: Company specializing in performing Work of this section with minimum ten years documented experience.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Store materials to permit easy access for inspection and identification. Support steel members off ground. Protect steel members and packaged materials from corrosion and deterioration. Materials showing evidence of damage will be rejected and shall be immediately removed from the site.
- B. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures. Repair or replace damaged materials or structures as directed.
- C. Do not handle structural steelwork until paint has thoroughly dried. Care shall be exercised to avoid abrasions and other damage.
- D. All fasteners and washers shall be delivered to the site, where they will be installed, in unopened containers.

PART 2 PRODUCTS

2.1 MATERIALS (*Equivalent Equal Acceptable*)

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Structural Steel Members: ASTM A36/A36M, ASTM A242/A242M, ASTM A514/A514M, ASTM A529/A529M, ASTM A568/A568M, and/or ASTM A572/A572M, Grade 40.
- C. Structural Tubing: ASTM A500 and/or ASTM A501.
- D. Pipe: ASTM A53/A53M, Grade B.
- E. Shear Stud Connectors: ASTM A449. Forged steel, headed, and/or unfinished.
- F. Suspension Cable: Wire rope.
- G. Sag Rods: ASTM A36/A36M.



- H. Bolts, Nuts, and Washers: ASTM A307, ASTM A325M bolts, ASTM A449 bolts, ASTM A490M bolts, ASTM A563 nuts, and/or galvanized to ASTM A123/A123M A153/A153M for galvanized structural members.
- I. Anchor Bolts: ASTM A307 for embedded anchors; and high strength bolts for chemically and mechanically anchored anchors.
- J. Welding Materials: AWS D1.1; type required for materials being welded.
- K. Sliding Bearing Plates: Teflon coated.
- L. Grout: Non-shrink type, pre-mixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing additives, capable of developing minimum compressive strength of 48 MPa at 28 days.
- M. Shop and Touch-Up Primer: SSPC 15, Type 1, red oxide.
- N. Touch-Up Primer for Galvanized Surfaces: SSPC 20, Type I: Inorganic, or Type II: Organic.

2.2 FABRICATION (*As Below Unless Agreed Otherwise With Owner*)

- A. General:
 - 1. Fabrication to be performed in accordance with Chapter M of AISC “Specification for Structural Steel Buildings” and the Drawings and Specifications.
 - a. Assume all thermally cut edges are subject to substantial stresses.
 - b. Paragraph M4.6 shall be considered deleted from Chapter M.
 - c. The last sentence of paragraph M5.1 shall be deleted.
 - 2. Provide holes and accessories required for securing other work to the work specified here.
 - 3. Where thickness of material exceeds 7/8 inch or the diameter of hole, drill or ream holes after punching even when punching is allowed by referenced standards. Flame cut holes for fasteners are not acceptable.
 - 4. Fabricate beams and girders with natural camber upward, unless otherwise shown or indicated on the Drawings.
 - 5. Splice members only where indicated on Structural Drawings or where accepted by the Architect.
 - 6. Remove burrs that would prevent solid seating of the connected parts.
- B. Architecturally Exposed Steel:
 - 1. All members exposed to view in the completed structure shall be classified as “Architecturally Exposed Structural Steel”.
 - 2. Comply with the provisions of the AISC Code of Standard Practice for Steel Buildings and Bridges regarding architecturally exposed structural steel.
 - a. Abutting cross sectional configurations shall match.
 - b. Remove backing bars.
 - c. Remove weld runoff tabs and grind smooth
 - d. All surfaces and welds exposed to view shall be treated as finished surfaces.



3. Exposed Welds:
 - a. All exposed fillet welds shall be made smooth of uniform convex contour, radius and dimension for their full length; grind smooth, if welds were not made to this criteria.
 - b. All other exposed welds shall be milled or ground smooth and flush with the surfaces of the adjoining materials welded.
 4. Weld show-through shall not be permitted.
 5. Remove weld splatter on architecturally exposed steel.
 6. All exposed corners shall be square and sharp, eased to a radius of 1/4 in.
- C. Bolting, General:
1. Bolts shall be of a length that will extend not less than 1/4 in beyond the nuts unless noted otherwise.
 2. Washers shall be used on Bolts. Use beveled washers where bolts bear on sloping surface.
 3. Bolts shall be installed such that no threads occur in the shear plane.
 4. Manufacturer's symbol and grade markings shall appear on all bolts and nuts.
 5. Product containers must be marked so that correspondence with mill reports can be established.
 6. Holes in column base-plates shall be no more than 1/8 inch larger than the nominal bolt size.
 7. Circular and slotted holes shall be as per Specification for Structural Joints Using ASTM A325 or A490 Bolts.
 8. When bolt holes are subject to welding shrinkage stresses the holes shall be drilled.
- D. Unfinished Bolts and Anchor Bolts:
1. Install and tighten unfinished bolts in accordance with requirements for snug tightened bolts as defined in "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
 2. Mutilate bolt threads for unfinished bolts to prevent the nuts from backing off.
- E. High-Strength Bolts:
1. Install high-strength threaded fasteners in accordance with RCSC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts". Contact surfaces of bolted parts shall as a minimum comply with the class A requirements.
 2. Unless otherwise noted, all connections are "slip critical (friction) type".
 3. Tighten nuts using Direct Tension Indicator. Calibrated wrench and "Turn of Nut" methods are not acceptable.
 4. When connection has bolts and welds, tighten bolts prior to welding with the exception that in moment connections the flange welds are completed prior to final tightening of high strength bolts.
 5. When already tensioned bolts have had their tension relaxed, either re-torque the bolts using a calibrated wrench or replace the bolt and/or tension indicator and re-tighten.



- F. Welding:
1. Welding shall be in accordance with AWS D1.1 “Structural Welding Code”.
 - a. Contractor is responsible for selection of specific materials and procedures except as specifically noted in contract documents.
 - b. Connections have varying levels of restraint and thus necessary steps shall be taken by Contractor to control or accommodate the restraint.
 - c. Welding and fabrication procedures shall incorporate measures necessary to eliminate cracking. These measures shall include but are not limited to additional preheat, postheat, or retarded cooling.
 - d. When selecting materials and procedures, consideration shall be given to the need for materials and procedures in excess of code requirements.
 - e. The need for pre-heat and other procedures are to be based on the actual chemistry and mechanical properties and not solely on the grade for which the steel was certified.
 - f. Weld variables shall be consistent with the recommendations of the electrode manufacturer.
 - g. Welding Procedure Specifications shall be readily available to all welders, inspectors, and supervisors.
 - h. Welding procedures shall incorporate low hydrogen practices.
 - i. Use stringer beads only (no weaving).
 2. No tack welds not incorporated into a weld will be allowed on the finished structure with the exception of backing plates that are not removed.
 3. All groove or butt welds shall be full penetration unless noted otherwise on the Drawings.
 4. Do not weld into column flange to column web intersection.
 5. Sequence the Work as necessary to accommodate testing.
 6. Remove-run-off tabs and backup plates and grind surfaces smooth as required for inspection or testing.
 7. At “special moment connection” or “eccentrically braced frame” connections:
 - a. Remove backing bars and apply reinforcing fillet weld per note J of figure 2.4 of AWS D1.1.
 - b. Remove weld runoff tabs and grind smooth.
 - c. Delete “...root and ...” from subsection 4.14.1.5 of AWS D1.1-94
 - d. Limit oscillation of FCAW electrodes to 3d, for $d \geq 3/32$ inches, and to 5d, for $d < 3/32$ inch (d = wire diameter).
 - e. Pay increased attention to uniform and adequate preheat.
 - f. Maximum interpass temperature not to exceed 550 degrees F when notch toughness properties are specified.
 - g. Complete individual weld layers prior to applying portions of subsequent layers. Ends of interrupted passes to be staggered. Minimize starts and stops within body of the weld.
 8. Splices of members in tension, that are made from ASTM A6 Group 4 of 5 rolled shapes, and or plates more than 2 inches thick shall be made in conformance with Section J1.7 of “Specification for Structural Steel Buildings ASD”, 9th Edition.
 9. Shear Studs: Install shear studs in accordance with the manufacturer’s recommendations and AWS D1.1
 10. Where tubes, pipes or other closed sections are exposed to the weather, provide seal welds where other specified welds do not provide a complete seal of the enclosed space.



G. Finishes of Architecturally Exposed Steel:

1. All surfaces of architecturally exposed structural steel members shall be uniform in appearance, including smoothness and texture, when viewed in direct sunlight at a distance of 10 feet, at angles of incidence 0 degree to 90 degree at completion of the following stages of work:
 - a. "Surface Preparation" and "Shop Prime Painting".
2. Surface Appearance: The initial condition of steel to be exposed in use shall conform to SSPC-V is 1 Rust Grade A. The exposed surfaces, edges and ends of all plates and other components shall be free of any surface defects including weld splatter, burrs, dents, gouges, occlusions, streak, ridges and recesses. Such defects may be repaired and surface restored with weld or other approved filler material and machining (milling, grinding or sanding) to match appearance, including smoothness and texture, of parent surface.
3. All surfaces to be grit blasted to SA 2½ (Swedish Standards).

H. Shop Painting:

1. All structural steel exposed to the weather, classified as Architecturally Exposed Steel, or not completely concealed by interior finishes shall receive a shop coat of primer except as follows:
 - a. Steel in contact with concrete.
 - b. Contact surfaces of welded connections and areas within 4 in on each side of field welds.
 - c. Machined surfaces.
 - d. Contact surfaces of high-strength bolted connections.
 - e. Reinforcing steel.
2. The following surfaces shall be temporarily protected by a thin coating of varnish or lacquer:
 - a. Unpainted areas around field welds.
 - b. Steel around high strength bolts.
 - c. Machined surfaces.

2.3 FINISH (*As Below Unless Agreed Otherwise With Owner*)

A. Finish of Painted Steel Surfaces:

1. Prepare structural component surfaces in accordance with SSPC.
2. Grit blast surfaces to SA 2½ (Swedish Standards).
3. Shop prime structural steel members. Do not prime surfaces that will be fireproofed, field welded, in contact with concrete or high strength bolted.
4. Apply an approved three-coat protective paint system; provide minimum ten (10) year maintenance free guarantee for the paint system.

B. Finish of Galvanized Steel Surfaces:

1. Prepare structural component surfaces in accordance with SSPC.
2. Galvanize structural steel members to ASTM A123/A123M. Furnish minimum 380g/m² galvanized coating.
3. Apply an approved mordant coat prior to receiving the protective paint system.
4. Apply an approved three-coat protective paint system; provide minimum ten (10) year maintenance free guarantee for the paint system.



2.4 SOURCE QUALITY CONTROL AND TESTS (*As Below Unless Agreed Otherwise With Owner*)

- A. Testing and inspection of structural steelwork will be performed by the independent testing agency cost of which shall be borne by Contractor. Provide the Inspector with the following.
 - 1. A complete set of accepted “Submittals”
 - 2. Cutting lists, order sheets, material bills, and shipping bills
 - 3. Representative sample pieces as requested by the testing agency
 - 4. full and ample means and assistance for testing all material
 - 5. Access and facilities, including scaffolding, temporary work platforms, etc., for testing and inspection at all places where materials or components are stored or fabricated, and also in their erected position.
- B. Scheduling of Tests and Inspections
 - 1. The Contractor shall notify the Inspector in sufficient time prior to fabrication or erection work to allow testing and inspection without delaying the work.
 - 2. Shop welds will be inspected in the shop before the work is painted or shipped.
- C. Each person installing connections shall be assigned an identifying symbol or mark and all shop and field connections shall be so identified so that the Inspector can refer back to the person making the connection.
- D. Non-destructive Testing and Inspections
 - 1. As a minimum the inspector shall make all tests and inspections as required by the 1997 Uniform Building Code Inspector will make all the tests and inspections indicated in the Construction Documents.
 - 2. The Inspector shall make all verification tests and inspections as required by AWS D1.1 “Structural Welding Code”.
 - 3. Do not reduce testing frequency unless permission is obtained from the Engineer.
 - 4. Inspector shall be present during all welding operations.
 - 5. Verify that welders are certified.
 - 6. Check materials, equipment and procedures. Verify meters on welding equipment are functioning and are accurate.
 - 7. Visual Inspection:
 - a. Visually inspect all welds.
 - b. Visual inspection of multi-pass welds to be continuous.
 - c. Visually inspect welds to Group 4 and 5 sections of at least 72 hours after completion of welding for the presence of cracks.
 - 8. Test Methods:
 - a. Butt welds will be tested using ultrasonic or radiographic test methods.
 - b. Butt welds to pipes and tubes to be tested using magnetic particle tests.
 - c. Use magnetic partial test methods for fillet welds and the supplement the testing requirements for butt welds.
 - d. At inspector’s option dye penetrant testing, and resistance testing methods may be used in place of or to supplement magnetic particle testing.



- e. For radiographic a double film technique will be used. One copy of each film will be sent to the Architect, the other will be retained by the Inspector.
 - f. In addition to the non-destructive testing specified other non-destructive test methods recognized by AWS D1.1 may be used at the Architects discretion and the results can be used to reject work under this contract.
9. Frequency of non-destructive examination is to be as follows:
- a. Full penetration butt welds: 100 percent.
 - b. Partial penetration butt welds with a leg length greater than 1/2 in: 20 percent min. ultrasonic or radiographic inspection.
 - c. Test 100 % of partial penetration butt welds used in column splices.
 - d. Test 20 % of total length of all welds joining web plates to flanges.
 - e. Fillet and other welds not otherwise addressed - a minimum of 10 %.
 - f. Selection of welds to be examined: Where there is a requirement for less than 100% examination the method of selection of welds to be examined is to be agreed with the Engineer before commencement of the work. If the Engineer does not provide more specific criteria inspectors will select the welds to be tested. The inspectors will chose specific weld so as to obtain results that are representative of the conditions in the structure. In addition inspectors will emphasize those locations that experience has shown are more likely to have problems.
 - g. On five percent of the full penetration butt welds as chosen by the inspector/engineer, after removing, run-off tabs, grind the end of the weld sufficiently to allow determination of number and sizes of weld passes.
10. Testing of Base Metal: These provisions are in addition to other applicable requirements.
- a. The edges of material to be welded will be ultrasonically examined for evidence of laminations, inclusions or other discontinuities.
 - b. Ultrasonically test column flanges and webs at the location of all moment connections and brace connections. Test for a distance 3 inches around the location to be welded. The test procedure and acceptance criteria is defined by ASTM A898-91, "Standard Specification for Straight Beam Ultrasonic Examination of Rolled Steel Structural Shapes" Level I.
 - c. Base metal thicker than 1½ inches, when subjected to through-thickness weld shrinkage strains, shall be ultrasonically inspected for discontinuities behind and within a distance of 3 inches of such welds after joint completion. Any material discontinuities shall be accepted or rejected on the basis of the defect rating in accordance with flaw severity, Class B criteria in Table 8.2 in AWS D1.1.
11. Where inspection reveals unacceptable defects:
- a. The extent of inspection will be increased as much as necessary to assure that the full extent of the defects in a joint has been found and to assure that the same defects are not present elsewhere.
 - b. As minimum, examine two additional joints in the group represented by the joint. If the non-destructive examination of the two additional joints reveals unacceptable defects, examine each joint in the group.



- E. Take samples of all welding consumables and store in sealed containers.
- F. Tests of high strength bolts, nuts and washers:
1. The Inspector will make all tests and inspections of high strength bolt connections as required by RCSC “Specifications for Structural Joints Using ASTM A 325 or A 490 Bolts”.
 2. Observe all Direct Tension Indicators to see if proper tightness was achieved.
 3. Confirm that the faying surfaces have been properly prepared before connections are assembled.
- G. Testing of End-Welded Studs:
1. End-welded studs shall be random sampled and tested from stock furnished to each project. Tests shall meet the requirements in Table 7.1 of AWS D1.1. The minimum number of tests of each required property shall be as follows:

Number of Pieces to Be Used from Identified Package	Number of Specimens
150 and less	1
151 to 280	2
281 to 500	3
501 to 1200	5
1201 to 3200	8
3201 to 10000	13
10001 and over	20

A minimum of three pieces from each lot shall be tested.
 2. Production control testing shall be in accordance with AWS D1.1 Chapter 7.
 3. As a minimum test, in accordance with AWS D1.1 paragraph 7.8, ten percent of all welded studs.
- H. Inspection Records
1. Make systematic record of all welds, including:
 - a. Location and type of weld.
 - b. Identification marks of welders.
 - c. List of defective welds.
 - d. Manner of correction of defects.
 2. The Inspector will maintain a daily record of the work that has been inspected and its disposition. One copy of each of the report will be submitted to the Owner on a weekly basis. Test reports will be made on the form suggested in the AWS D1.1 “Structural Welding Code”.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.



3.2 ERECTION

- A. Allow for erection loads, and for sufficient temporary bracing to maintain structure safe, plumb, and in alignment until completion of erection and installation of permanent bracing.
- B. Field weld components and shear studs as indicated on fabrication drawings.
- C. Field connect members with threaded fasteners; torque to required resistance tighten to snug tight for bearing type connections.
- D. Do not field cut or alter structural members without approval of the Engineer.
- E. After erection, prime welds, abrasions and surfaces not shop primed or galvanized, except surfaces to be in contact with concrete.
- F. Grout under base plates in accordance with Section 04065. Trowel grouted surface smooth, splay neatly to 45 degrees.

3.3 ERECTION TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation from Plumb: 6 mm per story, non-cumulative.
- C. Maximum Offset from Alignment: 6 mm.

3.4 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.

3.5 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 05500

METAL FABRICATIONS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes shop fabricated metal items.
- B. Related Sections:
 - 1. Section 03300 - Cast-In-Place Concrete.
 - 2. Section 07140 - Fluid Applied Waterproofing.
 - 3. Section 09900 - Paints and Coatings.

1.2 REFERENCES

- A. Aluminum Association:
 - 1. AA DAF-45 - Designation System for Aluminum Finishes.
- B. American Architectural Manufacturers Association:
 - 1. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum.
 - 2. AAMA 2603 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.
 - 3. AAMA 2604 - Voluntary specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.
 - 4. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
- C. ASTM International:
 - 1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
 - 2. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 3. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 4. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 5. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - 6. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.
 - 7. ASTM A297/A297M - Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application.
 - 8. ASTM A283/283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
 - 9. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60000 PSI Tensile Strength.



10. ASTM A312/A312M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes.
 11. ASTM A325M - Standard Specification for High-Strength Bolts for Structural Steel Joints (Metric).
 12. ASTM A354 - Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners.
 13. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
 14. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
 15. ASTM A554 - Standard Specification for Welded Stainless Steel Mechanical Tubing.
 16. ASTM B26/B26M - Standard Specification for Aluminum-Alloy Sand Castings.
 17. ASTM B85 - Standard Specification for Aluminum-Alloy Die Castings.
 18. ASTM B177 - Standard Guide for Chromium Electroplating on Steel for Engineering Use.
 19. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 20. ASTM B210M - Standard Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes (Metric).
 21. ASTM B211M - Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire (Metric).
 22. ASTM B221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric).
- D. American Welding Society:
1. AWS A2.4 - Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 2. AWS D1.1 - Structural Welding Code - Steel.
 3. AWS D1.6 - Structural Welding Code - Stainless Steel.
- E. National Ornamental & Miscellaneous Metals Association:
1. NOMMA Guideline 1 - Joint Finishes.
- F. The Society for Protective Coatings (SSPC):
1. SSPC - Steel Structures Painting Manual.
 2. SSPC SP 1 - Solvent Cleaning.
 3. SSPC SP 2 - Hand Tool Cleaning.
 4. SSPC SP 10 - Near-White Blast Cleaning.
 5. SSPC Paint 15 - Steel Joist Shop Paint.
 6. SSPC Paint 20 - Zinc-Rich Primers (Type I - Inorganic & Type II - Organic).

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate profiles, sizes, connection attachments, reinforcing, anchorage, size and type of fasteners, and accessories. Include erection drawings, elevations, and details where applicable. Indicate welded connections using standard AWS A2.0 welding symbols. Indicate net weld lengths.



- C. Shop Drawings for Slab edge Panels: Indicate dimensions, panel profile and layout, spans, joints, expansion joints, construction details, methods of anchorage, method and sequence of installation and interface with adjacent materials.
- D. Samples: Submit two samples of each metalwork type, size as directed by the Engineer, illustrating factory finishes.
- E. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.
- F. Design and Performance Data: Submit panel profile characteristics and dimensions, and structural properties. Submit design calculations.
- G. Manufacturer's Installation Instructions: Submit special handling criteria, installation sequence, and cleaning procedures.

1.4 QUALITY ASSURANCE

- A. Materials and work shall conform to the latest edition of reference specified herein and to applicable codes and requirements of local authorities having jurisdiction, including the following:
 - 1. The National Association of Architectural Metal Manufacturers (NAAMM)
 - a. Metal Finishes Manual
 - b. Metal Bar Grating Manual
 - c. Metal Products Outline Manual
- B. Qualify welding processes and welding operators in accordance with AWS D1.1 “Structural Welding Code – Steel,” D1.3 “Structural Welding Code – Sheet Steel”, and D1.2 “Structural Welding Code – Aluminum”.
- C. Structural Performance: Design, engineer, fabricate and install metal fabrications to withstand structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Comply with the “Performance Criteria” specified hereinafter.
- D. Conflicting Requirements: In the event of conflict between pertinent codes and regulations and the requirements of the referenced standards or these specifications, the provisions of the more stringent shall govern.
- E. Design cold-formed framing to comply with ASCE-7-95 and Uniform Building Code.
 - 1. Design Load for Exterior Wall assembly: Not less than 146 kg/m².
 - 2. Increase size of individual members, including anchorage, or reinforce to resist loads without undue deflection.
- F. Maximum Horizontal Deflection at Mid-Plan
 - 1. At Ceramic Tile: 10mm or L/600 of span based on moment of inertia of stud cross section only, whichever is less.
 - 2. Increase size of individual members, including anchorage, or reinforce to resist loads without undue deflection.
- G. Sloped Sills: Size to resist wind loads plus anticipated live loads of 195 kg/m², but not less than 1.5mm thick.



- H. Interior Locations Indicated as Structural Steel Stud: Size to resist anticipated loads, but not less than 0.9mm thick unless otherwise indicated.
- I. Differential Movement: Design and construct wall system to accommodate anticipated movement indicated herein, without damage or deterioration to studs or wallboards, without buckling, opening of joints, and cracking.
- J. Certifications: Work of this Section shall be performed under the direct supervision of a registered Professional Engineer.
- K. Perform Work in accordance with the drawings and to the approval of the Engineer.
- L. Maintain one copy of each document on site.

1.5 QUALIFICATIONS

- A. Design under direct supervision of Professional Engineer experienced in design of this Work and approved by the Engineer.
- B. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.
- C. Installer: Company specializing in performing Work of this section with minimum five years documented experience.

1.6 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for product storage and handling.
- B. Accept metal fabrications on site in labeled shipments. Inspect for damage.
- C. Protect metal fabrications from damage by exposure to weather.

1.7 FIELD MEASUREMENTS

- A. Verify field measurements are as indicated on shop drawings, and/or as instructed by the manufacturer.

PART 2 PRODUCTS

2.1 MATERIALS - STEEL

- A. Steel Sections: ASTM A36/A36M.
- B. Steel Tubing: ASTM A500, Grade B, and/or ASTM A501.
- C. Plates: ASTM A283/A283M.
- D. Pipe: ASTM A53/A53M, Grade B, Schedule 40.
- E. Fasteners: as instructed by the manufacturer.



- F. Bolts, Nuts, and Washers: ASTM A325M, A307 and/or galvanized to ASTM A153/A153M for galvanized components.
- G. Welding Materials: AWS D1.1; type required for materials being welded.
- H. Shop and Touch-Up Primer: SSPC Paint 15, Type 1, red oxide.
- I. Touch-Up Primer for Galvanized Surfaces: SSPC Paint 20 Type I Inorganic and/or Type II Organic zinc rich.

2.2 MATERIALS - STAINLESS STEEL

- A. Bars and Shapes: ASTM A276, and/or ASTM A479/A479M; Type 316.
- B. Tubing: ASTM A269, and/or ASTM A554; Type 316.
- C. Pipe: ASTM A312/A312M, seamless and/or welded; Type 316.
- D. Plate, Sheet and Strip: ASTM A167; Type 316.
- E. Bolts, Nuts, and Washers: ASTM A354.
- F. Welding Materials: AWS D1.6; type required for materials being welded.

2.3 MATERIALS - ALUMINUM

- A. Extruded Aluminum: ASTM B221M, Alloy 6063, Temper T5.
- B. Sheet Aluminum: ASTM B209M.
- C. Aluminum-Alloy Drawn Seamless Tubes: ASTM B210M, Alloy 6063, Temper T6.
- D. Aluminum-Alloy Bars: ASTM B211M, Alloy 6063, Temper T6.
- E. Aluminum-Alloy Sand Castings: ASTM B26/B26M.
- F. Aluminum-Alloy Die Castings: ASTM B85.
- G. Bolts, Nuts, and Washers: Stainless steel type 316.
- H. Welding Materials: AWS D1.1; type required for materials being welded.

2.4 ISOLATING NON-CONDUCTIVE MATERIALS BETWEEN DISSIMILAR METALS

- A. Contacts between dissimilar metals should be avoided in order to prevent bi-metallic or galvanic corrosion.
- B. Dissimilar metals shall be isolated from each other with non-conductive materials. Generally, such isolating elements will take the form of washers and bushes.



- C. Isolated Non-Conductive Materials: Neoprene, synthetic resin bonded fiber (SRBF) such as tufnol, polytetrafluoroethylene (PTFE), or hard nylon, depending on the fixing:
 - 1. Load Bearing Fixings: SRBF or PTFE (strong material).
 - 2. Restraint Fixings: Neoprene or nylon is acceptable.
- D. Electrical insulation tape and bitumen paint are considered in low risk short life application, and shall not be used as non-conductive materials unless directed by the Engineer.

2.5 STRUCTURAL SUPPORTS

- A. Structural Supports for Miscellaneous Attachments: Steel sections, shape and size as indicated on Drawings, required to support applied loads (Dead & Live) with maximum deflection of 1/200 of the span; prime paint, one coat or mill finish.

2.6 ANCHOR BOLTS

- A. Anchor Bolts: ASTM A307; steel bolt, standard J-hook, with nut and washer; unfinished.

2.7 FABRICATION

- A. Fit and shop assemble items in largest practical sections, for delivery to site.
- B. Fabricate items with joints tightly fitted and secured.
- C. Continuously seal joined members by intermittent welds and plastic filler and/or continuous welds.
- D. Exposed Welded Joints: NOMMA Guideline 1 Joint Finish.
- E. Exposed Mechanical Fastenings: Flush countersunk screws or bolts; unobtrusively located; consistent with component design, except where specially noted otherwise.
- F. Supply components required for anchorage of fabrications. Fabricate anchors and related components of same material and finish as fabrication, except where specifically noted otherwise.

2.8 FACTORY APPLIED FINISHES - STEEL

- A. Prepare surfaces to be primed in accordance with SSPC SP 2.
- B. Clean surfaces of rust, scale, grease, and foreign matter prior to finishing.
- C. Do not prime surfaces in contact with concrete or where field welding is required.
- D. Prime paint items with one or two coats except where galvanizing is specified.
- E. Galvanized Structural Steel Members: Galvanize after fabrication to ASTM A123. Furnish minimum 380 g/sq m galvanized coating.



- F. Galvanized Non-structural Items: Galvanized after fabrication to ASTM A123. Furnish minimum 380 and/or 360 g/m² galvanized coating.
- G. Chrome Plating: ASTM B177, nickel-chromium alloy, satin and/or polished finish.

2.9 FACTORY APPLIED FINISHES - STAINLESS STEEL

- A. Satin Polished Finish: Number 4, satin directional polish parallel with long dimension of finished face. Color: As selected.
- B. Mirror Polished Finish: Number 8, mirror polish with preliminary directional polish lines removed. Color: As selected.

2.10 FACTORY APPLIED FINISHES - ALUMINUM

- A. Finish coatings to conform to AAMA 2603, 2604, 2605 and/or AAMA 611. Comply with AA DAF-45.
- B. Exterior and Interior Aluminum Surfaces: Advanced Durability Polyester Powder Coating System. Color: As selected. Minimum cover thickness 60 microns. Gloss Percentage: As selected.
- C. Apply one coat of bituminous paint to concealed aluminum surfaces in contact with cementitious or dissimilar materials.

2.11 FABRICATION TOLERANCES

- A. Squareness: 3 mm maximum difference in diagonal measurements.
- B. Maximum Offset between Faces: 1.5 mm.
- C. Maximum Misalignment of Adjacent Members: 1.5 mm.
- D. Maximum Bow: 3 mm in 1.2 m.
- E. Maximum Deviation from Plane: 1.5 mm in 1.2 m.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify field conditions are acceptable and are ready to receive Work.

3.2 PREPARATION

- A. Clean and strip primed steel items to bare metal where site welding is required.



- B. Supply steel items required to be cast into concrete, or embedded in masonry with setting templates to appropriate sections.

3.3 INSTALLATION

- A. Install work of this section square, plumb, straight, true to line or radius, accurately fitted and located, with flush tight hairline joints (except as indicated otherwise or to allow for thermal movement). Provide attachment devices as required for secure and rigid installation.
- B. Exposed joints shall be close fitting, and bolts and screws, where exposed, shall be cut off flush with nuts or other adjacent metal. Cutting, drilling, punching and tapping required for the installation and attachment of other work to miscellaneous metal work, except where specified in connection with work under other sections, shall be performed as required.
- C. Metal work built-in with concrete or masonry shall be formed for anchorage, or be provided with suitable anchors, expansion shields or other anchoring devices shown on the drawings, or required. Such metal work shall be furnished in ample time for setting and securing in place. Wherever possible fixings shall be built into concrete.
- D. Where indicated, install miscellaneous metal items in sleeves (furnished under this section) embedded in concrete with setting grout specified herein.
- E. Joints shall be as strong and rigid as adjoining sections. Welding shall be continuous along entire line of contact, except where spot welding is indicated or permitted. Where exposed, welds shall be ground smooth. Where bolted or riveted connections are indicated, such connections may be welded at the Contractor's option.
- F. Where welding is required, it shall conform to requirements for shielded metal arc welding of the Standard Code for Arc and Gas Welding of the American Welding Society. Exposed welds shall be flush and ground smooth.
- G. Threaded connections shall be made up tight so that threads are entirely concealed. Abutting bars shall be so shouldered and headed, doweled and pinned. Small bars shall pass through larger bars and pinned. Rivet, bolts and screw heads shall be flat and countersunk in exposed work and elsewhere as required. Removable members shall be carefully machined and fitted and secured, by means of screws or bolts of proper size and approved spacing.
- H. Bolts, brackets, sleeves and other items embedded in concrete shall be galvanized.
- I. Except where built in fixings cannot be used miscellaneous metal work may be fastened to concrete with expansion bolts and to hollow with toggle bolts. Fastening to wood plugs in concrete or masonry will not be permitted. Holes for plugs or bolts shall be drilled to the exact diameter of the plug or bolt, using a percussion drill for concrete and a rotary drill for masonry. Screws shall be threaded full length to the head of the screw.
- J. Provide for adjustments of miscellaneous metal items, with particular attention given to miscellaneous steel supporting the work of other sections, as required during the construction process.



- K. Install isolating non-conductive materials between dissimilar metals as per approved methodology.
- L. Setting Loose Plates:
 - 1. Clean concrete and masonry bearing surfaces of any bond-reducing materials, roughen to improve bond to surfaces. Clean bottom surface of bearing plates.
 - 2. Set loose leveling and bearing plates on wedges, or other adjustable devices. After the bearing members have been positioned and plumbed, tighten the anchor bolts. Do not remove wedges or shims, but if protruding, cut off flush with the edge of the bearing plate before packing with grout.
 - 3. Pack grout solidly between bearing surfaces & plates. Ensure no voids remain
- M. Butt welds or splice butt joints in track. Splices in axial loaded studs shall not be permitted. Welds shall be fillet, plug, butt, or seam.
 - 1. Secure floor and ceiling runners to structure with power driven anchors spaced not over 400mm on center and 150mm maximum from ends. Closer spacing at discretion of stud manufacturer based on design loads.
 - 2. Provide elastomeric sealant or sill sealer material between concrete structure and ceiling and floor runner channels at exterior.
- N. Slide Clip Detail: Provide flexible connection between studs and building structure to accommodate slab edge deflection and long term building creep without transferring axial load to studs.
- O. Installation of Slab Edge Panels:
 - 1. Protect panel surfaces in contact with cementitious materials and dissimilar metals with bituminous paint. Allow to dry prior to installation.
 - 2. Permanently fasten panel system to structural supports; aligned, level, and plumb, within specified tolerances.
 - 3. Locate panel joints over supports.
 - 4. Install control joints where required.
 - 5. Use concealed fasteners wherever possible.
 - 6. Seal and place gaskets to prevent weather penetration. Maintain neat appearance.
- P. Obtain approval of the Engineer prior to site cutting or making adjustments not scheduled.
- Q. After erection, touch up welds, abrasions, and damaged finishes with prime paint or galvanizing repair paint to match shop finishes.

3.4 ERECTION TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation from Plumb: 6 mm per story or for every 3.65 m in height whichever is greater, non-cumulative.
- C. Maximum Offset from Alignment: 6 mm.
- D. Maximum Out-of-Position: 6 mm.



- E. Maximum Variation of Wall from Plumb, Level or True-to-Line: 3mm in 3m.

3.5 CLEANING

- A. General Requirements: Execution requirements for final cleaning.
- B. Remove site cuttings from finish surfaces.
- C. Clean & wash prefinished surfaces with mild soap and water; rinse with clean water.

END OF SECTION



SECTION 07130

SHEET WATERPROOFING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes waterproofing membrane, drainage panels and protective cover.
- B. Related Sections:
 - 1. Section 02320 - Backfill.
 - 2. Section 07212 - Board Insulation.
 - 3. Section 07620 - Sheet Metal Flashing and Trim.
 - 4. Section 07900 - Joint Sealers.
 - 5. Division 15 - Mechanical: Plumbing fixtures and plumbing specialties.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers -Tension.
 - 2. ASTM D449 - Standard Specification for Asphalt Used in Dampproofing and Waterproofing.
 - 3. ASTM D450 - Standard Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing.
 - 4. ASTM D471 - Standard Test Method for Rubber Property-Effect of Liquids.
 - 5. ASTM D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
 - 6. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
 - 7. ASTM D822 - Standard Practice for Conducting Tests on Paint and Related Coatings and Materials Using Filtered Open-Flame Carbon-Arc Exposure Apparatus.
 - 8. ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
 - 9. ASTM D2240 - Standard Test Method for Rubber Property-Durometer Hardness.
 - 10. ASTM D2581 - Standard Specification for Polybutylene (PB) Plastics Molding and Extrusion Materials.
 - 11. ASTM D4068 - Standard Specification for Chlorinated Polyethylene (CPE) Sheeting for Concealed Water-Containment Membrane.
 - 12. ASTM D4551 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Flexible Concealed Water-Containment Membrane.
 - 13. ASTM D4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.
 - 14. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.



- B. National Roofing Contractors Association:
 - 1. NRCA - The NRCA Waterproofing and Dampproofing Manual.

1.3 SYSTEM DESCRIPTION

- A. Waterproofing System: Capable of resisting existing water head with the required factor of safety and preventing moisture migration to interior.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate special joint or termination conditions and conditions of interface with other materials.
- C. Product Data: Submit data for surface conditioner, flexible flashings, joint cover sheet, and joint and crack sealants, with temperature range for application of waterproofing membrane.
- D. Manufacturer's Installation Instructions: Submit special procedures and perimeter conditions requiring special attention.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with NRCA Waterproofing Manual.
- B. Test material samples in accordance with ASTM D449 and ASTM D450.
- C. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Membrane Manufacturer: Company specializing in waterproofing sheet membranes with minimum fifteen years documented experience.
- B. Applicator: Company specializing in performing work of this section with minimum ten years documented experience.

1.7 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct Mockup, 10 m² of horizontal and vertical panels; to represent finished work with internal and external corners, seam jointing, attachment method, counterflashing cover, drainage panel, base flashings, control/expansion joints, and protective cover.
- C. Locate where directed by the Engineer.



- D. Remove mockup when directed by the Engineer.

1.8 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.9 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Maintain ambient temperatures above 5°C for 24 hours before and during application and until liquid or mastic accessories have cured.

1.10 WARRANTY

- A. General Requirements: Execution requirements for product warranties and bonds.
- B. Provide ten year warranty for each waterproofing system including coverage of materials and installation, and all resulting damage resulting from failure to resist penetration of moisture.
- C. For warranty repair work, remove and replace materials concealing waterproofing.

PART 2 PRODUCTS

2.1 SHEET MEMBRANE WATERPROOFING

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 COMPONENTS

- A. Rubber Membrane: Butylene conforming to ASTM D2581, EPDM conforming to ASTM D4637 Type I and/or Chloroprene/neoprene conforming to ASTM D4637 Type II; 1.8 mm thick; Class SR: Scrim or fabric internal reinforced, exposed face color and roll width as per manufacturer's recommendations; with compatible seam tape and termination bar; conforming to following below criteria:
- B. Plastic Membrane: PVC conforming to ASTM D4551, HDPE, Ethylene Copolymer, CPE conforming to ASTM D4068, CSPE conforming to ASTM D4068, and/or Hypalon; 2 mm thick unless otherwise stated; roll width as per manufacturer's recommendations; with compatible seam tape and termination bar; conforming to following below criteria.
- C. Modified Bituminous Membrane: Asphalt and polymer modifiers of styrene-butadiene-styrene (SBS), and/or atactic polypropylene (APP) type, reinforced with non-woven polyester, fiber glass, polyethylene and/or polypropylene; smooth surfaced; thickness and roll width as per manufacturer's recommendations; with compatible seam tape and termination bar; conforming to following below criteria.



- D. Composite HDPE/Bentonite Sheet Membrane: Comprised of black/grey or clear HDPE and granular bentonite with spun polypropylene fabric facing; minimum thickness of 3.8 mm; 1200 mm wide roll; with compatible water stop devices, 100 mm wide rubberized asphalt seam tape, and extruded aluminum termination bar; conforming to following below criteria.
- E. Criteria:
- | 1. | <u>Properties</u> | <u>Test</u> |
|----|-----------------------------|------------------------|
| a. | Tensile Strength | ASTM D412 |
| b. | Elongation | ASTM D412 |
| c. | Hardness - Shore A | ASTM D2240 |
| d. | Tear Strength | ASTM D624 and/or D1004 |
| e. | Water Absorption | ASTM D471 |
| f. | Moisture Vapor (perms) | ASTM E96 |
| g. | Exposure at Low Temperature | ASTM D822 |
| h. | Brittleness | ASTM D746 |
- F. Seaming Materials: As recommended by membrane manufacturer.
- G. Flexible Flashings: As recommended by membrane manufacturer.

2.3 ACCESSORIES

- A. Surface Conditioner: type compatible with membrane, as recommended by membrane manufacturer.
- B. Adhesives: As recommended by membrane manufacturer.
- C. Thinner and Cleaner: As recommended by adhesive manufacturer, compatible with sheet membrane.
- D. Battens: As recommended by membrane manufacturer.
- E. Disc Washers and Screws: As recommended by membrane manufacturer.
- F. Circular Membrane Discs: As recommended by membrane manufacturer.
- G. Reglet Strip Devices: As recommended by membrane manufacturer.
- H. Sealant: As stated in Section 07900 and as recommended by membrane manufacturer.
- I. Mortar Beveled Corners (Fillet) at Intersections:
1. Portland Cement: ASTM C150, Type I, gray color.
 2. Fine Aggregate: ASTM C144 and/or C404.
 3. Water: Clean and potable.
 4. Calcium chloride is not permitted.
 5. Thoroughly mix mortar ingredients in accordance with ASTM C270 in quantities needed for immediate use.
 6. Achieve uniformly damp sand immediately before mixing process.
 7. Add admixtures in accordance with manufacturer's instructions to achieve uniformity of mix and coloration.
 8. Re-temper only within two hours of mixing.



- J. Protective Covers:
 - 1. For Horizontal Surfaces: Unless otherwise stated or shown on the drawings, heavy duty rigid polypropylene protection boards specified in Section 07212, or cement sand screed, mix (1:3).
 - 2. For Vertical Surfaces: Unless otherwise stated or shown on the drawings, heavy duty rigid polypropylene protection boards specified in Section 07212.
- K. Cant Strips: Premolded composition material and/or Bitumen impregnated fiberboard.
- L. Flexible Flashings: As recommended by membrane manufacturer.
- M. Counterflashings: as specified in Section 07620.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify substrate surfaces are durable; free of matter detrimental to adhesion or application of waterproofing system.
- C. Verify items penetrating surfaces to receive waterproofing are securely installed.
- D. Verify substrate surface slopes to drain for horizontal waterproofing applications.

3.2 PREPARATION

- A. Protect adjacent surfaces not designated to receive waterproofing.
- B. Execute cement sand mortar at all intersections to make beveled corners (fillet) of size 50 x 50 mm.
- C. Clean and prepare surfaces to receive waterproofing.
 - 1. Surfaces shall be clean and without any holes, lips, angular ridges, unstable sandy areas, and the like (holes shall be flush filled, and lips, aggressive ridges, projections, etc. shall be flushed by grinding).
- D. Do not apply waterproofing to surfaces unacceptable to manufacturer or applicator.
- E. Seal cracks and joints with sealant materials using depth to width ratio as recommended by sealant manufacturer and in accordance with Section 07900.
- F. Apply surface conditioner at rate recommended by manufacturer. Protect conditioner from rain or frost until dry.

3.3 INSTALLATION - GENERAL

- A. Install Work in accordance with the drawings, to the manufacturer's instructions and to the approval of the Engineer.



3.4 INSTALLATION - LOOSE LAID MEMBRANE WATERPROOFING

- A. Roll out membrane. Minimize wrinkles and bubbles.
- B. Overlap edges and ends and seal by solvent welding, heat welding, contact tape and/or contact adhesive, minimum 75 mm. Seal permanently waterproof. Apply uniform bead of sealant to joint edge.
- C. Reinforce membrane with multiple thicknesses of membrane material over static or moving joints.
- D. Weather lap joints on sloped substrate in direction of drainage. Seal joints and seams.
- E. Install flexible flashings. Seal watertight to membrane.
- F. Seal flashings to adjoining surfaces.
- G. Extend membrane over cants and up intersecting surfaces at membrane perimeter minimum 200 mm above horizontal surface for first ply and as recommended by the manufacturer at subsequent plies laid in shingle fashion.
- H. Terminate top edge of membrane and flexible flashing under counterflashings, seal with mastic. Coordinate with metal flashing installation specified in Section 07620.
- I. Particular Requirements for Loose Laid PVC Membrane Waterproofing:
 - 1. The overlapping and assembly of PVC membrane shall be carried out by heated wedge thermal welding as instructed by the manufacturer.
 - 2. Each stop end (casting edge) shall be fitted with a rear guard type PVC waterstop. The axis of the stop end shall correspond to the waterstop axis.
 - 3. Where two or more stop ends meet, the waterstops shall be mitered and welded together in a manner to form an approved continuous profile even at right angle corners perpendicular to each other. The rear guard type waterstops will themselves be continuously welded on the PVC membrane to compartmentalize the waterproofing membrane between waterstops.
 - 4. Additional longitudinal and transverse partitioning shall be installed to limit compartments to under 150 m² as per manufacturer's recommendations.
 - 5. A stainless steel device shall be provided above each dewatering well (if any), to enable the termination of PVC membrane, and later, to allow the removal of pumps and well closure in accordance with a methodology approved by the Engineer.
 - 6. A control / injection pipes and stainless steel or inox covers system as per manufacturer's recommendations shall be provided to allow repair of damaged waterproofing section (Layout of injection pipes and covers to be approved by the Engineer).
 - 7. Two layers of anti-punching geotextile fabrics shall be provided as per manufacturer's recommendations; 500 to 700 g/m² each for horizontal surfaces, and 1000 g/m² each for vertical surfaces.
 - 8. Polyethylene sheet, 0.25 mm thick, shall be provided for horizontal surfaces.
 - 9. PVC protective sheet to membrane shall be provided, 1.5 or 2 mm thick.



3.5 INSTALLATION - ADHESIVE BONDED, SELF ADHERED AND TORCH APPLIED MEMBRANE WATERPROOFING

- A. Roll out membrane. Minimize wrinkles and bubbles.
- B. Remove release paper layer. Roll out on substrate with mechanical roller to encourage full contact bond.
- C. Apply adhesive at rate recommended by manufacturer, Bond sheet to substrate except those areas directly over or within 75 mm of control or expansion joint.
- D. Apply membrane by torch application, coated side down.
- E. Lap sides and ends.
- F. Overlap edges and ends and seal with contact adhesive, or by heat sealing, minimum 75 mm. Seal permanently waterproof. Apply uniform bead of sealant to joint edge.
- G. Reinforce membrane with multiple thickness of membrane material over joints, whether joints are static or dynamic.
- H. Weather lap joints on sloped substrate in direction of drainage. Seal joints and seams. Coordinate with drain installation, Division 15 - Mechanical.
- I. Install flexible flashings. Seal watertight to membrane.
- J. Seal membrane and flashings to adjoining surfaces.
- K. Extend membrane over cants and up intersecting surfaces at membrane perimeter minimum 200 mm above horizontal surface for first ply and as recommended by the manufacturer at subsequent plies laid in shingle fashion.
- L. Seal items protruding to or penetrating through membrane and install Counterflashing membrane material.

3.6 INSTALLATION - MECHANICALLY ATTACHED MEMBRANE WATERPROOFING

- A. Roll out membrane. Minimize wrinkles and bubbles.
- B. Install mechanical fasteners in accordance with applicable code.
- C. Bond sheet to membrane disc.
- D. Overlap edges and ends and seal by solvent welding, heat welding, contact tape and/or contact adhesive, minimum 75 mm. Seal permanently waterproof. Apply uniform bead of sealant to joint edge.
- E. Weather lap joints on sloped substrate in direction of drainage. Seal joints and seams.
- F. Install flexible flashings. Seal watertight to membrane.
- G. Seal membrane and flashings to adjoining surfaces.



- H. Extend membrane over cants and up intersecting surfaces at membrane perimeter minimum 200 mm above horizontal surface for first ply and as recommended by the manufacturer at subsequent plies laid in shingle fashion.
- I. Seal items protruding to or penetrating through membrane and install Counterflashing membrane material.

3.7 INSTALLATION - DRAINAGE PANEL AND PROTECTION BOARD

- A. Place drainage panel directly against membrane, butt joints, place to encourage drainage downward.
- B. Place protection board directly against drainage panel and/or membrane; butt joints.
- C. Adhere protection board and drainage panel to substrate with mastic to tacky dampproofing surface. Scribe and cut boards around projections, penetrations, and interruptions.

3.8 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. On completion of horizontal membrane installation, dam installation area in preparation for flood testing.
- C. Flood to minimum depth of 25 mm with clean water. After 48 hours, inspect for leaks.
- D. When leaking is found, remove water, repair leaking areas with new waterproofing materials as directed by the Engineer; repeat flood test. Repair damage to building.
- E. When area is proven watertight, drain water and remove dam.

3.9 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Do not permit traffic over unprotected or uncovered membrane.
- C. Protect membrane from damage by adhering protection board over membrane surface. Scribe and cut boards around projections and interruptions.

3.10 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07140

FLUID-APPLIED WATERPROOFING

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes fluid applied rubberized asphalt and/or elastomeric membrane waterproofing, and polyurethane waterproof coating system; and surface dusting and/or protective covering.
- B. Related Sections:
 - 1. Section 02320 - Backfill.
 - 2. Section 07212 - Board Insulation: Perimeter and horizontal insulation protective cover.
 - 3. Section 07620 - Sheet Metal Flashing and Trim.
 - 4. Section 07900 - Joint Sealers.
 - 5. Division 15 - Mechanical: Plumbing fixtures and plumbing specialties.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM C836 - Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course.
 - 2. ASTM D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers -Tension.
 - 3. ASTM D429 - Standard Test Method for Rubber Property - Adhesion to Rigid Substrates.
 - 4. ASTM D471 - Standard Test Method for Rubber Property - Effect of Liquids.
 - 5. ASTM D624 - Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
 - 6. ASTM D746 - Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
 - 7. ASTM D822 - Standard Practice for Conducting Tests on Paint and Related Coatings and Materials Using Filtered Open-Flame Carbon-Arc Exposure Apparatus.
 - 8. ASTM D1004 - Standard Test Method for Initial Tear Resistance of Plastic Film and Sheeting.
 - 9. ASTM D2240 - Standard Test Method for Rubber Property-Durometer Hardness.
 - 10. ASTM D3468 - Standard Specification for Liquid-Applied Neoprene and Chlorosulfonated Polyethylene Used in Roofing and Waterproofing.
 - 11. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- B. National Roofing Contractors Association:
 - 1. NRCA - The NRCA Waterproofing and Dampproofing Manual.



1.3 SYSTEM DESCRIPTION

- A. Waterproofing System: Fluid applied material to prevent moisture migration to interior.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate special joint or termination conditions and conditions of interface with other materials.
- C. Product Data: Submit data for surface conditioner, flexible flashings, joint cover sheet, and joint and crack sealants, with temperature range for application of waterproofing membrane.
- D. Manufacturer's Installation Instructions: Submit special procedures and perimeter conditions requiring special attention.
- E. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with NRCA Waterproofing Manual.
- B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Waterproofing Material Manufacturer: Company specializing in waterproofing membrane with minimum fifteen years documented experience.
- B. Applicator: Company specializing in performing the work of this section with minimum ten years documented experience.

1.7 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct Mockup, 10 sq m of horizontal and vertical waterproofed panel; to represent finished work including internal and external corners, jointing, attachment method, flashings, drainage panel, base flashings, control and expansion joints, and protective cover.
- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.



1.8 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.9 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Maintain ambient temperatures above 5 °C for 24 hours before and during application and until liquid or mastic accessories have cured.

1.10 WARRANTY

- A. General Requirements: Execution requirements for product warranties and bonds.
- B. Furnish ten year manufacturer warranty for waterproofing failing to resist penetration of water.
- C. For warranty repair work, remove and replace materials concealing waterproofing.

PART 2 PRODUCTS

2.1 FLUID APPLIED WATERPROOFING

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 BITUMINOUS COLD APPLIED WATERPROOFING PAINT

- A. Waterproofing Membrane: Rubberized asphalt or elastomeric membrane; fluid applied, cold applied; quick setting.

- B. Cured Membrane Characteristics:

1.	<u>Properties</u>	<u>Test</u>
a.	Tensile Strength	ASTM D412
b.	Elongation	ASTM D412
c.	Hardness - Shore A	ASTM D2240
d.	Tear Strength	ASTM D624 and/or D1004
e.	Water Absorption	ASTM D471
f.	Moisture Vapor (perms)	ASTM E96
g.	Exposure at Low Temperature	ASTM D822
h.	Brittleness	ASTM D746
i.	Adhesion	ASTM D429

2.3 POLYURETHANE WATERPROOF COATING SYSTEM

- A. Polyurethane solvent-free waterproof flexible coating, two coats, each 1.5 kg/m².



2.4 ACCESSORIES

- A. Surface Conditioner and/or Primer: type compatible with membrane compound; as recommended by membrane manufacturer.
- B. Elastic Flashings: 1.2 mm thick, as recommended by membrane manufacturer.
- C. Joint Cover Sheet: Elastic sheet material designated for and compatible with membrane. Thickness as recommended by membrane manufacturer.
- D. Cant Strips: Premolded composition material, as recommended by membrane manufacturer.
- E. Drainage Panel: As recommended by membrane manufacturer.
- F. Joint and Crack Sealant: As recommended by membrane manufacturer.
- G. Back-up Material: As recommended by membrane manufacturer.
- H. Reglet Strip Devices: As recommended by membrane manufacturer.
- I. Counterflashings: As recommended by membrane manufacturer.
- J. Tack-free Surfacing: Type 1 Portland cement and/or Stone dust.
- K. Separation Sheet: As recommended by membrane manufacturer.
- L. Protection Board: 2mm thick polypropylene boards, as specified in Section 07212.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify substrate surfaces are free of frozen matter, dampness, loose particles, cracks, pits, projections, penetrations, or foreign matter detrimental to adhesion or application of waterproofing system.
- C. Verify substrate surfaces are smooth, free of honeycomb or pitting, and not detrimental to full contact bond of waterproofing materials.
- D. Verify items penetrating surfaces to receive waterproofing are securely installed.
- E. Verify substrate surface slopes to drain for horizontal waterproofing applications.

3.2 PREPARATION

- A. Protect adjacent surfaces not designated to receive waterproofing.



- B. Execute cement sand mortar at all intersections to make beveled corners (fillet) of size 50 x 50 mm.
- C. Clean and prepare surfaces to receive waterproofing.
 - 1. Surfaces shall be clean and without any holes, lips, angular ridges, unstable sandy areas, and the like (holes shall be flush filled, and lips, aggressive ridges, projections, etc. shall be flushed by grinding).
- D. Do not apply waterproofing to surfaces unacceptable to manufacturer or applicator.
- E. Seal cracks and joints with sealant materials using depth to width ratio as recommended by sealant manufacturer and/or in accordance with Section 07900.
- F. Apply surface conditioner at rate recommended by manufacturer. Protect conditioner from rain or frost until dry.

3.3 INSTALLATION

- A. Apply 300 mm wide strip of joint cover sheet over cracks, non-working joints, and expansion joints over 1.6 mm but not exceeding 13 mm in width.
- B. At expansion joints from 13 to 25 mm in width, loop cover sheet down into joint between 31 and 44 mm. Extend sheet 200 mm on both sides of expansion joint.
- C. Center cover sheet over crack or joints. Roll sheet into 3.2 mm coating of waterproofing material. Apply second coat over sheet extending minimum of 200 mm beyond sheet edges. Apply this procedure especially to expansion joints between horizontal and vertical surfaces.
- D. Apply waterproofing material.
- E. Apply and spread waterproofing material to a minimum cured thickness and averaging thickness as recommended by the manufacturer.
- F. Extend membrane over cants and up intersecting surfaces at membrane perimeter minimum 200 mm above horizontal surface.
- G. Install cant strips at inside corners.
- H. Apply extra thickness of waterproofing material at corners, intersections, angles, and over joints.
- I. Seal items protruding to or penetrating through membrane and install counter-flashing membrane material.
- J. Extend waterproofing material and flexible flashing into drain clamp flange and apply adequate coating of liquid membrane to assure clamp ring seal. Coordinate with drain installation specified in Division 15 - Mechanical.
- K. Install membrane flashings and seal into waterproofing material.
- L. Conform to NRCA - Waterproofing Manual drawing details as noted:



- M. Place drainage panel directly against membrane, butt joints, place to encourage drainage downward.
- N. Place protection board and/or panel directly against drainage panel and/or membrane; butt joints.
- O. Adhere protection board and/or drainage panel to substrate with mastic. Scribe and cut boards around projections, penetrations, and interruptions.
- P. Install Work in accordance with the drawings, to the manufacturer's instructions and to the approval of the Engineer.

3.4 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. On completion of membrane installation, dam installation area as directed by the Engineer, in preparation for flood testing.
- C. Flood to minimum depth of 25 mm with clean water. After 48 hours, verify no leaks with the Engineer.
- D. When leaking is found, remove water, patch leaking areas with new waterproofing materials as directed by the Engineer; repeat flood test. Repair damage to building.
- E. When area is proven watertight, drain water and remove dam.

3.5 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Do not permit traffic over unprotected or uncovered membrane.
- C. After membrane has cooled and/or cured, but before it becomes dusty, apply separation sheet. Lap joints to ensure complete coverage.

3.6 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07212

BOARD INSULATION

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes rigid and semi-rigid board insulation and integral vapor retarder at cavity wall construction, perimeter foundation wall, underside of floor slabs, exterior walls, etc.
- B. Related Sections:
 - 1. Section 07260 - Vapor Retarders: Vapor retarder materials to adjacent insulation.
 - 2. Section 07270 - Air Barriers: Air seal materials to adjacent insulation.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM C240 - Standard Test Methods of Testing Cellular Glass Insulation Block.
 - 2. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.
 - 3. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
 - 4. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
 - 5. ASTM C1289 - Standard Specification for Faced Rigid Cellular Thermal Insulation Board.
 - 6. ASTM D2842 - Standard Test Method for Water Absorption of Rigid Cellular Plastics.
 - 7. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 8. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- B. National Fire Protection Association:
 - 1. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- C. Underwriters Laboratories Inc.:
 - 1. UL 723 - Tests for Surface Burning Characteristics of Building Materials.

1.3 SYSTEM DESCRIPTION

- A. Materials of this Section:
 - 1. Provide continuity of thermal barrier at building enclosure elements.
 - 2. Provide thermal protection to vapor retarder in conjunction with vapor retarder materials in Section 07260.
 - 3. Provide thermal protection to air seal materials at building enclosure elements in conjunction with air barrier materials in Section 07270.



1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data on product characteristics, performance criteria, limitations, and adhesives.
- C. Manufacturer's Installation Instructions: Submit special environmental conditions required for installation techniques.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Do not install adhesives when temperature or weather conditions are detrimental.

1.6 SEQUENCING

- A. Sequence Work to ensure fireproofing, firestopping, vapor retarder, and air barrier materials are in place before beginning Work of this section.

1.7 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate Work with Section 07260 and Section 07270.

PART 2 PRODUCTS

2.1 BOARD INSULATION

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 COMPONENTS

- A. Polypropylene Protection Board: Two spaced layers, joined together with ribs:
 - 1. 1.5 mm thick; Unit weight: 250g/m².
 - 2. 5 mm thick; Unit weight: 650g/m².
- B. Extruded Polystyrene Insulation Board: ASTM C578, type VII, cellular type:
 - 1. Board Density: 35 kg/m³.
 - 2. Board Size and Thickness: 1200 mm x 2400 mm x 50 mm thick.
 - 3. Thermal Resistance: RSI of 0.87.
 - 4. Water Absorption: To ASTM D2842, 0.3 percent by volume maximum.
 - 5. Compressive Strength: Minimum 175 kPa.
 - 6. Board Edges: Square, shiplap, or tongue and groove edges.
 - 7. Flame/Smoke Properties: In accordance with ASTM E84.



2.3 ACCESSORIES

- A. Adhesive Type 1: Type recommended by insulation manufacturer for application.
- B. Adhesive Type 2: Vapor retarder type, trowel consistency; fire retardant compatible with insulation and substrate, as recommended by the manufacturer.
- C. Sheet Vapor Retarder: Specified in Section 07260.
- D. Tape: Bright aluminum, Polyethylene and/or Polyester self-adhering type, mesh reinforced, 50 mm wide.
- E. Insulation Fasteners: Impaling clip as recommended by the manufacturer to be adhered and/or mechanically fastened to surface to receive board insulation, length to suit insulation thickness and substrate, capable of securely and rigidly fastening insulation in place.
- F. Protective Boards: As recommended by the manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify substrate, adjacent materials, and insulation boards are dry and ready to receive insulation and adhesive.
- C. Verify substrate surface is flat, free of honeycomb, fins, irregularities, and materials or substances affecting adhesive bond.

3.2 INSTALLATION

- A. Install Work in accordance with the drawings, to the manufacturer's instructions and to the satisfaction of the Engineer.

3.3 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Do not permit damage to insulation prior to covering.

3.4 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07260

VAPOR RETARDERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes sheet and sealant materials for controlling vapor diffusion.
- B. Related Sections:
 - 1. Section 07270 - Air Barriers.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.
 - 2. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- B. Sealant, Waterproofing and Restoration Institute:
 - 1. SWRI - Sealant Specification.

1.3 PERFORMANCE REQUIREMENTS

- A. Maximum Vapor Permeability (Perm): 1 ng/S/m/Pa measured in accordance with ASTM E96 Method E.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data indicating material characteristics, performance criteria, and limitations.
- C. Manufacturer's Installation Instructions: Submit preparation and installation requirements, techniques.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with SWRI - Sealant and Caulking Guide Specification requirements for materials and installation.

1.6 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mock-up, size as directed by the Engineer, of exterior wall, ceiling and attic vapor retarder including vapor retarder installation at typical window, door and wall-ceiling intersection.



- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.

1.7 SEQUENCING

- A. Sequence Work to permit installation of materials in conjunction with other retardant materials and seals, and air barrier assemblies specified in Section 07270.
- B. Do not install vapor retarder until items penetrating vapor retarder are in place.

PART 2 PRODUCTS

2.1 VAPOR RETARDERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 COMPONENTS

- A. Sheet Retarder: Polyethylene film for above grade application, minimum 0.25 mm thick.
- B. Sealant: Type recommended by the Manufacturer.
- C. Primer and Backer Rods: As recommended by sealant manufacturer to suit application.
- D. Cleaner: Non-corrosive type; as recommended by sealant manufacturer; compatible with adjacent materials.
- E. Mastic Adhesive: asphalt type, compatible with sheet retarder and substrate, as recommended by manufacturer.
- F. Adhesive: Compatible with sheet retarder and substrate, permanently non-curing, as recommended by manufacturer.

2.3 ACCESSORIES

- A. Thinner and Cleaner: As recommended by sheet material manufacturer.
- B. Tape: Bright aluminum, Polyethylene and/or Polyester self-adhering type, mesh reinforced, 50 mm wide, compatible with sheet material.
- C. Attachments: Stainless steel type 316 bars and anchors.



PART 3 EXECUTION

3.1 PREPARATION

- A. Remove loose or foreign matter capable of impairing adhesion.
- B. Clean and prime substrate surfaces to receive adhesive and sealants.

3.2 EXISTING WORK

- A. Clean and repair existing construction to provide positive and continuous seal for vapor retarders.

3.3 INSTALLATION

- A. Install Work in accordance with the drawings, to the manufacturer's instructions and to the approval of the Engineer.

3.4 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07270

AIR BARRIERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes air leakage criteria for primary air seal building enclosure materials and assemblies; materials and installation methods supplementing other and primary air seal materials and assemblies; and air seal materials to connect and seal openings, joints, and junctions between other air seal materials and assemblies.
- B. Related Sections:
 - 1. Section 07260 - Vapor Retarders: Vapor retarders.
 - 2. Section 07900 - Joint Sealers: Sealant materials and installation techniques.

1.2 REFERENCES

- A. American Society of Civil Engineers:
 - 1. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
- B. ASTM International:
 - 1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - 2. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.
 - 3. ASTM E283 - Standard Test Method for Determining the Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences across the Specimen.
 - 4. ASTM E330 - Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference.
- C. Sealant, Waterproofing and Restoration Institute:
 - 1. SWRI - Sealant Specification.

1.3 DEFINITIONS

- A. Air Barrier: Continuous network of materials and joints providing air tightness, with adequate strength and stiffness to not deflect excessively under air pressure differences, to which it will be subjected in service. It can be comprised of single material or combination of materials to achieve performance requirements.

1.4 DESIGN REQUIREMENTS

- A. Perform design work in accordance with ASCE 7.



1.5 PERFORMANCE REQUIREMENTS

- A. Static Test: Resist air leakage caused by static air pressure across exterior wall assemblies and other interruptions to integrity of building enclosure systems; in accordance with ASTM E283 and/or ASTM E330.
- B. Dynamic Test: Resist air leakage caused by dynamic air pressure across exterior wall assemblies and other interruptions to integrity of wall and roof systems; in accordance with ASTM E283 and/or ASTM E330.
- C. Provide continuity of air seal materials and assemblies in conjunction with materials described in Division 3, Division 7 and Division 8.

1.6 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate special joint conditions.
- C. Design Data: Submit design calculations.
- D. Product Data: Submit data on material characteristics, performance criteria and limitations.
- E. Manufacturer's Installation Instructions: Submit preparation, installation requirements and techniques, product storage and handling criteria.

1.7 QUALITY ASSURANCE

- A. Perform Work to SWRI - Sealant and Caulking Guide Specification requirements.
- B. Maintain one copy of each document on site.

1.8 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mock-up of air barrier system, which is comprised of variety of materials.
- C. Construct typical exterior wall panel, size as directed by the Engineer, incorporating window frame and sill, insulation, building corner condition, junction with roof membrane air seal, and vapor retarder; illustrating materials interface and seals.
- D. Locate where directed by the Engineer.
- E. Remove mockup when directed by the Engineer.

1.9 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.



1.10 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Maintain temperature and humidity recommended by materials manufacturers before, during and after installation.

1.11 SEQUENCING

- A. Sequence Work to permit installation of materials in conjunction with related materials and seals.

1.12 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate the Work of this section with sections referencing this section.

PART 2 PRODUCTS

2.1 AIR BARRIERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 COMPONENTS

- A. Sheet Seal: Type as recommended by the manufacturer.
- B. Liquid Seal: Type as recommended by the manufacturer.
- C. Sealant: Type as recommended by the manufacturer.
- D. Polysulfide Sealant: Type as recommended by the manufacturer.
- E. Polyurethane Sealant: Type as recommended by the manufacturer.
- F. Silicone Sealant: Type as recommended by the manufacturer.
- G. Primer: As recommended by the manufacturer.
- H. Substrate Cleaner: Non-corrosive, type as recommended by sealant manufacturer, compatible with adjacent materials.
- I. Mastic Adhesive: Compatible with sheet seal and substrate, as recommended by the manufacturer.
- J. Adhesive: Type compatible with sheet seal and substrate, permanently non-curing; As recommended by the manufacturer.



2.3 ACCESSORIES

- A. Thinner and Cleaner for Sheet: As recommended by sheet material manufacturer.
- B. Tape: Bright aluminum, Polyethylene and/or Polyester self adhering type, mesh reinforced, 50 mm wide, compatible with sheet material.
- C. Attachments: Stainless steel type 316 bars and anchors.

PART 3 EXECUTION

3.1 PREPARATION

- A. Clean and prime substrate surfaces to receive adhesive and sealants.

3.2 INSTALLATION

- A. Install Work in accordance with the drawings, to the manufacturer's instructions and to the approval of the Engineer.

3.3 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Do not permit adjacent work to damage work of this section.

3.4 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07613

MANUFACTURED SHEET METAL ROOFING

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Factory formed structural and architectural sheet metal roofing panels with concealed or exposed fasteners; standing seam or lapped seam.
 - 2. Metal gutters and downspouts.
 - 3. Structural supports.
- B. Related Sections:
 - 1. Section 03100 - Concrete Forms and Accessories: Placement of flashing reglets and accessories.
 - 2. Section 05120 - Structural Steel: Structural support for metal roofing panels.
 - 3. Section 07900 - Joint Sealers.
 - 4. Section 09900 - Painting and Coatings: Field painting.

1.2 REFERENCES (*Equivalent Equal Acceptable*)

- A. American Architectural Manufacturers Association:
 - 1. AAMA 2603 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.
 - 2. AAMA 2604 - Voluntary specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.
 - 3. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
- B. American Iron and Steel Institute:
 - 1. AISI SG-973 - Cold-Formed Steel Design Manual.
- C. American Society of Civil Engineers:
 - 1. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
- D. ASTM International:
 - 1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 2. ASTM A755/A755M - Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products.
 - 3. ASTM A792/A792M - Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.
 - 4. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).



5. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 6. ASTM D2178 - Standard Specification for Asphalt Glass Felt Used in Roofing and Waterproofing.
 7. ASTM D4397 - Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.
 8. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free.
 9. ASTM E283 - Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
 10. ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Curtain Walls, and Doors By Uniform Static Air Pressure Difference.
- E. Federal Specification Unit:
1. FS TT-C-494 - Coating Compound, Bituminous, Solvent Type, Acid Resistant.
- F. National Roofing Contractors Association:
1. NRCA - The NRCA Roofing and Waterproofing Manual.
- G. Sheet Metal and Air Conditioning Contractors:
1. SMACNA - Architectural Sheet Metal Manual.
- H. Underwriters Laboratories Inc.:
1. UL 580 - Tests for Uplift Resistance of Roof Assemblies.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Fabrication Drawings:
1. Indicate metal roofing and soffit panel profiles, jointing patterns, jointing details, fastening methods, flashings, terminations and installation details.
- C. Product Data:
1. Submit data on metal types, finishes and characteristics.
 2. Submit color charts for finish selection.
- D. Samples:
1. Submit two samples 300 x 300 mm in size illustrating metal finish color.
- E. Manufacturer's Installation Instructions: Submit instructions including special procedures for roofing penetrations, flashings and perimeter conditions requiring special attention.
- F. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE (*Equivalent Equal Acceptable*)

- A. Calculate structural properties of framing members in accordance with AISI SG-973.



- B. Perform Work in accordance with SMACNA Architectural Sheet Metal Manual and The NRCA Roofing and Waterproofing Manual.
- C. Perform Work in accordance with the drawings and to the satisfaction of the Engineer.
- D. Maintain one copy of each document on site.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum five years documented experience.

1.6 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup of sheet metal roofing and soffits, 3000 mm long by 3000 mm wide, including structural supports, gutters and downspouts, associated attachments, flashings, joints and junctions, control or expansion joints, and terminating items.
- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.

1.7 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.8 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for transporting, handling, storing, and protecting products.
- B. Stack material to prevent twisting, bending, and abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.
- C. Prevent contact with materials causing discoloration or staining.

1.9 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

1.10 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.



- B. Coordinate with Work of Section 03100 for installing recessed flashing reglets.
- C. Coordinate with Work of Section 05120 for erection of structural steel supports for sheet metal roofing panels.

1.11 WARRANTY

- A. General Requirements: Execution requirements for warranties.
- B. Furnish five year manufacturer warranty for sheet metal roofing against structural failure, corrosion and water penetration.
- C. Furnish five year manufacturer warranty for metal finish against fading, chipping, chalking and blistering.

PART 2 PRODUCTS (*Equivalent Equal Acceptable*)

2.1 MANUFACTURED SHEET METAL ROOFING

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Furnish materials in accordance with the drawings and to the satisfaction of the Engineer.
- C. Metal Roofing Panels:
 - 1. Factory formed metal roofing panel system with concealed fasteners.
 - 2. The prepainted roof and wall panels shall be 26 gauge (0.5 mm nominal thickness) galvanized steel, roll formed to Butlerib II configuration or equal.
 - a. The steel shall have a minimum yield of 42 ksi (29 kN/cm²) and shall conform to ASTM A446 Grade C.
 - b. The zinc coating is achieved through a continuous hot dip galvanizing process that equals to or exceeds ASTM A525, class G90 (0.90 oz/ft² or 275 g/m²).
 - c. The exterior surface shall be precision coated with a thermosetting silicone-type finish to a dry film thickness of 1 ± 0.2 mils (25 ± 5 microns).
 - d. The interior surface shall be coated with a thermosetting polyester coat.
 - 3. Panel Width, Profile, and Joint: As per drawings.
 - 4. Color: As selected.

2.2 SHEET METAL MATERIALS

- A. Pre-Finished Galvanized Steel Sheet: ASTM A755/A755M coil coated.
 - 1. Base Metal: ASTM A653/A653M; Structural Quality; Z275 zinc coating.
 - 2. Exposed Finish: As directed or shown on the drawings.

2.3 STRUCTURAL SUPPORTS

- A. Structural Supports: As specified in Section 05120.



2.4 ACCESSORIES

A. Fasteners:

1. Same material and finish as roofing metal, with soft neoprene washers where exposed.
2. Roof and wall fasteners shall be No. 14 x 3/4" hexagonal head self tapping carbon steel and case hardened screws. These fasteners shall be electrogalvanized per ASTM A164 Type LS (0.5 mils or 12.5 microns minimum thickness), and shall have a chromate film applied with bronze appearance. These fasteners shall have metal backed neoprene washers for positive seal.

B. Sealant:

1. The panlastic bead sealant used at roof panel side, and end laps shall be a 1/4" x 3/16" performed non-skinning elastic bead sealant based on butyl elastomers.
2. The panlastic cartridge type sealant used at roof panel end splices, shall be a single component solvent release type, non-skinning elastic sealant based on butyl elastomers.

C. Gable Trim and Eave Trim:

1. The gable and eave trims shall be of the "Butler Contour" type or similar approved and shall be fabricated from 26 gauge (0.5mm) galvanized steel. Galvanization shall be to latest issue of ASTM A525 specifications, G90 coating (0.90 oz/ft² or 275 g/m²).
2. The gable and eave trims shall be prepainted similar to the panels to a colour chosen by the owner.
3. Preformed rubber weather-seals shall be installed to completely fill the roof panel corrugation voids prior to the installation of the eave trim.

D. Gutters and Down Spouts:

1. Gutters shall be fabricated from 24 gauge (0.607mm) galvanized steel. Galvanization shall be to latest issue of ASTM A525, G90 coating (275 g/m²).
2. The gutter shall be prepainted similar to the panels to a colour to be chosen by the owner.
3. The gutter shall be supported by galvanized steel hangers from the roof panels.
4. Preformed corner closures shall be provided to match the configuration of the gable trim and gutter.
5. The gutter shall have a minimum width as shown on the drawings.
6. Downspouts shall consist of a 100mm diameter pipes, gutter outlets, straps and elbows.
7. Pipes and elbows shall be made of 26 gauge (0.5mm) galvanized steel, prepainted similar to the panels to a colour chosen by the owner.

E. Fascias:

1. The fascia system shall be open or with soffit as specified or shown on the drawings.
2. The fascia shall be available for installation on wide span buildings up to 120 feet (36,576mm) wide.



3. The fascia panel shall be Butlerib II, 26 gauge (0.5mm) prepainted panel.
 4. The fascia with soffit shall have a weatheguard panel. The soffit panel shall be Butlerib II, 26 gauge (0.5mm) prepainted panel.
- F. Insulation:
1. Insulation shall be glass fiber blanket composed of stable and uniformly textured inorganic glass fibers bonded together by a non-water soluble and fire retardant thermosetting resin. The insulation shall be supplied in rolls of 3 feet (910 mm) widths with the facing extending and additional 2" (50 mm) each side.
 2. The insulation thickness shall be 50 mm. The facing shall be white vinyl.
 3. The density of the insulation shall be 10 to 12 kg/m³ standard nominal density with a thermal conductivity of 0.40 W/M °C.
- G. Reglets: Surface mounted or recessed type, galvanized steel or rigid extruded PVC; face and ends covered with plastic tape.
- H. Splash Pans: Same metal type as downspouts, of size as per drawings.
- I. Protective Backing Paint: As per drawings.

2.5 FABRICATION

- A. Form sections shape as indicated on drawings, accurate in size, square and free from distortion or defects.
- B. Fabricate fascia, trim, flashing, and other metal components from same material as metal roof panels. Provide exposed metal surfaces with same finish as exposed face of metal roof panels.
- C. Fabricate cleats of same material as sheet, to interlock with sheet.
- D. Fabricate starter strips of same material as sheet, continuous, to interlock with sheet.
- E. Form pieces in single length sheets.
- F. Hem exposed edges on underside 13 mm; miter and seam corners.
- G. At moving joints, use sealed lapped, bayonet-type or interlocking hooked seams.
- H. Fabricate corners from one piece with minimum 450 mm long legs; seam for rigidity, seal with sealant.
- I. Fabricate vertical faces with bottom edge formed outward 6 mm and hemmed to form drip.
- J. Fabricate flashings to allow toe to extend over roofing gravel or paver. Return and brake edges.
- K. Fabricate gutters to profile and size as indicated on drawings.
- L. Fabricate downspouts to profile and size as indicated on drawings.



- M. Fabricate supplementary accessories in profile and size to suit gutters and downspouts (for large gutter girth):
 - 1. Anchorage Devices: Recommended by fabricator complying with SMACNA.
 - 2. Gutter Supports: Brackets, straps, or Spikes and ferrules.
 - 3. Downspout Supports: Brackets, or straps.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Wood and Metal Deck Substrate:
 - 1. Inspect roof deck to verify deck is clean and smooth, free of depressions, waves, or projections, and properly sloped.
 - 2. Verify deck is dry. Verify substrate joints are solidly supported and fastened.
 - 3. Verify wood nailers are installed and correctly located.
- C. Structural Framing Substrate:
 - 1. Verify primary and secondary framing members are installed and fastened, properly aligned and sloped.
 - 2. Verify damaged shop coatings are repaired with touch up paint.
- D. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set, reglets are in place, and nailing strips located.
- E. Verify roofing termination and base flashings are in place, sealed and secure.
- F. Verify insulation is installed and ready for roof application.

3.2 PREPARATION

- A. Wood and Metal Deck Substrate:
 - 1. Fill knot holes and surface cracks with latex filler.
- B. Back paint concealed metal surfaces and surfaces in contact with dissimilar metals with protective backing paint to minimum dry film thickness of 0.4 mm.

3.3 INSTALLATION - STRUCTURAL SUPPORTS

- A. Install structural supports as shown on drawings and as specified in section 05120.
- B. Align supports with top surface in plane, uniformly sloped.
- C. Install supports as per drawings. Provide support at roof panel end laps.
- D. Secure supports to building structural frame by welding or with mechanical fasteners and/or as shown on drawings.



3.4 INSTALLATION - METAL ROOFING PANELS

- A. Install perimeter trim, level and aligned perpendicular or parallel with fascia.
- B. Install soffit panels to form flat, flush surface.
- C. Fit soffit panels in single length between perimeter trim. Secure panels to soffit framing and/or substrate.
- D. Install perforated panels at locations indicated on Drawings.
- E. Adjust panels for uniform joints.
- F. Install Work in accordance with the drawings and to the satisfaction of the Engineer.

3.5 INSTALLATION - FLASHING

- A. Install reglets in accordance with Section 03100.

3.6 INSTALLATION - GUTTERS AND DOWNSPOUTS

- A. Built-In Gutters:
 - 1. Secure gutter lining to substrate with cleats spaced minimum 910 mm on center, unless otherwise stated, along edges of gutters.
 - 2. Longitudinal joints not acceptable.
 - 3. At roof edges, extend gutter lining under metal roofing 150 mm minimum and terminate in 19 mm folded edge secured by cleats. Hook lower end of roofing into lock strip to form 19 mm wide loose-lock seam.
- B. Secure gutters and downspouts in place using concealed fasteners.
- C. Slope gutters minimum 20 mm/m (2%).
- D. Seal gutters watertight. Seal joint of gutter to drain.
- E. Connect downspouts to rain water system, unless otherwise shown on drawings. Seal connection watertight.
- F. Set splash pans or pads under downspouts. Secure in place.

3.7 CLADDING

- A. All cladding and associated work shall be supplied and installed by the Contractor or by a specialist cladding Sub-Contractor having the appropriate experience and qualifications, who shall be responsible for the preparation of shop drawings, for supply and erection drawings and for the installation. Both sets of drawing shall be submitted to the Engineer for approval.
- B. Full coordination shall be undertaken with the supplier of structural steel work so that member spacing suits cladding requirements.



- C. The cladding supplier and erector shall guarantee a complete watertightness and weathertightness. Special attention shall be paid to end and/or side laps of cladding. Where required special sealant shall be utilized in conformity with the manufacturers' standard details. In particular where the roof slope is less than 5°, where required bitumastic sealer shall be incorporated in such laps in accordance with the sheeting manufacturer's recommendations.
- D. Care shall be taken in the storing and handling of cladding and ancillary items and no damaged cladding shall be incorporated into the works. The touch up on site of any damaged coatings will only be allowed when specifically approved by the Engineer or his representative. If approved, the coating used shall be that supplied by the sheeting manufacturer to match precisely any factory applied surfacings.
- E. Notwithstanding the specified maintenance requirements for the works, the specialist cladding Sub-Contractor shall guarantee the weathertightness of the whole of the cladded elements for a period of five years calculated from the time that the works are substantially complete. The Contractor will be deemed to have included for the provision of such guarantee in his rates.
- F. The cost of supplying and erecting all flashings and trims are deemed to be included in the Contractor's unit rates.

3.8 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Do not permit traffic over unprotected roof surface.

3.9 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07620

SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes flashings and counterflashings, sheet metal roofing and fabricated sheet metal items, as indicated in Schedule.
 - 1. Provide reglets and accessories, precast concrete splash pads, and/or sheet metal splash pans.
- B. Related Sections:
 - 1. Section 03100 - Concrete Forms and Accessories: Placement of recessed flashing reglets and accessories.
 - 2. Section 04810 - Unit Masonry Assemblies: Through-wall flashings in masonry.
 - 3. Section 07900 - Joint Sealers.
 - 4. Section 09900 - Paints and Coatings: Field painting.
 - 5. Division 15 - Mechanical: Hangers and Supports.

1.2 REFERENCES

- A. American Architectural Manufacturers Association:
 - 1. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum.
 - 2. AAMA 2603 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.
 - 3. AAMA 2604 - Voluntary specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.
 - 4. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
- B. ASTM International:
 - 1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - 2. ASTM A666 - Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
 - 3. ASTM A924/A924M - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
 - 4. ASTM B32 - Standard Specification for Solder Metal.
 - 5. ASTM B101 - Standard Specification for Lead-Coated Copper Sheet and Strip for Building Construction.
 - 6. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
 - 7. ASTM B370 - Standard Specification for Copper Sheet and Strip for Building Construction.



8. ASTM B749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.
 9. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 10. ASTM D4397 - Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.
 11. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free.
- C. Copper Development Association Inc.:
1. CDA - Copper in Architecture - Handbook.
- D. Federal Specification Unit:
1. FS TT-C-494 - Coating Compound, Bituminous, Solvent Type, Acid Resistant.
- E. Sheet Metal and Air Conditioning Contractors:
1. SMACNA - Architectural Sheet Metal Manual.

1.3 DESIGN REQUIREMENTS

- A. Sheet Metal Flashings: Conform to the criteria of SMACNA "Architectural Sheet Metal Manual" and/or Copper Development Association "Copper in Architecture - Handbook".
- B. Gutter and Downspout Components: Conform to SMACNA Manual, CDA Handbook, SSINA Standard Practice, and/or NRCA Details for sizing components for rainfall intensity determined by storm occurrence of 1 in 5 years.
- C. Maintain one copy of each document on site.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate material profile, jointing pattern, jointing details, fastening methods, flashings, terminations, and installation details.
- C. Product Data: Submit data on manufactured components metal types, finishes, and characteristics.
- D. Samples:
1. Submit two samples, size as directed by the Engineer, illustrating seam, external and/or internal corners, valley, ridge, junction to vertical dissimilar surface, material and finish.

1.5 QUALIFICATIONS

- A. Fabricator and Installer: Company specializing in sheet metal work with minimum ten years documented experience.



1.6 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.7 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for product storage and handling.
- B. Stack material to prevent twisting, bending, and abrasion, and to provide ventilation. Slope metal sheets to ensure drainage.
- C. Prevent contact with materials causing discoloration or staining.

1.8 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate with Work of Section 03100 and Section 04810 for installing recessed flashing reglets.

PART 2 PRODUCTS

2.1 SHEET METAL FLASHING AND TRIM

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Aluminum Sheet: ASTM B209M, alloy and temper as required for application and finish; 1.2 mm thick unless otherwise stated; finish and color as selected by the Engineer.

2.2 ACCESSORIES

- A. Fasteners: Same material and finish as flashing metal.
- B. Underlayment: ASTM D4397, 0.25 mm polyethylene.
- C. Slip Sheet: As recommended by manufacturer.
- D. Primer: As recommended by manufacturer.
- E. Protective Backing Paint: As recommended by manufacturer.
- F. Sealant: Type as specified in Section 07900.
- G. Plastic Cement: ASTM D4586, Type I.
- H. Reglets: As recommended by manufacturer.



- I. Splash Pads: Precast concrete type, of sizes and profiles as indicated; minimum 29 MPa at 28 days, with minimum 5 percent air entrainment.
- J. Downspout Boots and/or Shoes: As recommended by manufacturer.
- K. Solder: ASTM B32; type suitable for application and material being soldered.

2.3 FABRICATION

- A. Form sections shape indicated on Drawings, accurate in size, square and free from distortion or defects.
- B. Fabricate cleats of same material as sheet metal, interlocking with sheet.
- C. Form pieces in single length sheets.
- D. Hem exposed edges on underside 13 mm; miter and seam corners.
- E. Form material with standing, batten and/or flat lock seams, except where otherwise indicated. At moving joints, use sealed lapped, bayonet-type or interlocking hooked seams.
- F. Tin edges of copper sheet to be soldered. Solder shop formed metal joints. After soldering, remove flux. Wipe and wash solder joints clean. Weather seal joints.
- G. Fabricate corners from one piece with minimum 450 mm long legs; seam and/or solder for rigidity, seal with sealant.
- H. Fabricate vertical faces with bottom edge formed outward 6 mm and hemmed to form drip.
- I. Fabricate flashings to allow toe to extend 50 mm over roofing gravel and/or paver. Return and brake edges.
- J. Fabricate guards as detailed on drawings.
- K. Fabricate gutters to profile and size indicated.
- L. Fabricate downspouts to profile and size indicated.
- M. Fabricate accessories in profile and size to suit gutters and downspouts.
 - 1. Anchorage Devices: Type recommended by fabricator.
 - 2. Gutter Supports: Type recommended by fabricator.
 - 3. Downspout Supports: Type recommended by fabricator.
- N. Fabricate splash pans of same metal type as downspouts, dimension as recommended by fabricator.
- O. Seal metal joints.



2.4 FACTORY FINISHING

- A. Factory Finish: as recommended by finish system manufacturer.
- B. Primer Coat: Finish concealed side of metal sheets with primer compatible with finish system, as recommended by finish system manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, reglets in place, and nailing strips located.
- C. Verify roofing termination and base flashings are in place, sealed, and secure.

3.2 PREPARATION

- A. Install starter and edge strips, and cleats before starting installation.
- B. Install surface mounted reglets to lines and levels indicated on Drawings. Seal top of reglets with sealant.
- C. Paint concealed metal surfaces with protective backing paint to minimum dry film thickness of 0.4 mm.

3.3 INSTALLATION

- A. Install work in accordance with the drawings, to the manufacturer's recommendations and to the approval of the Engineer.

3.4 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Inspection will involve surveillance of Work during installation to ascertain compliance with specified requirements.

3.5 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 07900

JOINT SEALERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes sealants and joint backing, precompressed foam sealers, hollow gaskets and accessories.
- B. Related Sections:
 - 1. Section 03300 - Cast-in-Place Concrete.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM C834 - Standard Specification for Latex Sealants.
 - 2. ASTM C919 - Standard Practice for Use of Sealants in Acoustical Applications.
 - 3. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.
 - 4. ASTM C1193 - Standard Guide for Use of Joint Sealants.
 - 5. ASTM D1056 - Standard Specification for Flexible Cellular Materials- Sponge or Expanded Rubber.
 - 6. ASTM D1667 - Standard Specification for Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
 - 7. ASTM D2628 - Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Products Data: Submit data indicating sealant chemical characteristics, performance criteria, substrate preparation, limitations, and color availability.
- C. Samples: Submit samples illustrating sealant colors for selection.
- D. Manufacturer's Installation Instructions: Submit special procedures, surface preparation, and perimeter conditions requiring special attention.
- E. Warranty: Include coverage for installed sealants and accessories failing to achieve airtight seal or watertight seal, exhibit loss of adhesion or cohesion, and sealants which do not cure.

1.4 QUALITY ASSURANCE

- A. General Joint Sealer Performance Requirements: Select materials for compatibility with joint surfaces and other indicated exposures.
 - 1. Select modulus of elasticity and hardness or grade recommended by manufacturer for each application indicated.



2. Where exposed to foot traffic, select materials of sufficient strength and hardness to withstand stiletto heel traffic without damage or deterioration of sealer system.
- B. Color Selection: Provide colors indicated and if not, to match adjacent material or paint color; provide custom colors where required; colors to be selected by Engineer.
- C. Perform work in accordance with sealant manufacturers' requirements for preparation of surfaces and material installation instructions.
- D. Contractor shall require sealant manufacturer to review joint conditions and details, and shall submit to the Engineer written certification from the sealant manufacturer that joints are of the proper size and design, that the materials and backing will properly perform to provide permanent watertight, airtight or vaportight seals (as applicable), and that materials supplied meet specified performance requirements.
 1. Certification shall include copies of manufacturer's test regarding adhesion and staining of adjacent surfaces.
- E. Perform acoustical sealant application work in accordance with ASTM C919.
- F. Maintain one copy of each referenced document on site.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.
- B. Applicator: Company specializing in performing Work of this section with minimum five years documented experience.

1.6 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup of sealant joints in conjunction with window, wall and other mockups specified in other sections.
- C. Construct mockup with specified sealant types and with other components noted.
 1. Determine preparation and priming requirements based on manufacturer's recommendations; take action necessary for correction of failure of sealant tests on mock-up.
 2. Verify sealants, primers and other components don't stain adjacent materials.
- D. Locate where directed by the Engineer.
- E. Remove mockup when directed by the Engineer.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Products requirements.



- B. Maintain temperature and humidity recommended by sealant manufacturer during and after installation.

1.8 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate Work with sections referencing this section.

PART 2 PRODUCTS

2.1 JOINT SEALERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. General:
 - 1. Provide a complete system of cleaners, primers, fillers, tapes, backer rods and tapes and sealants in accordance with the manufacturer's requirements and the standards specified herein.
 - 2. Color of Sealants:
 - a. For Concealed Joints: Provide the manufacturer's standard color which has the best overall performance quantities for the application shown.
 - b. For Exposed Joints: Provide custom colors as selected by the Engineer from the manufacturer's standard colors or other special custom colors.
- C. 2-Part Polyurethane Sealant: Polyurethane based 2-part elastomeric sealant, in accordance and complying with Fed. Spec. TT-S-00227, Type II, Class A, with elongation and compression of not less than 25 %; ASTM C920, Type M, Class 25, Grade NS.
 - 1. Location: Exterior joints within masonry and concrete.
 - 2. Acceptable Manufacturers and Product:
 - a. Tremco: Dymeric.
 - b. Sonneborn Building Products: Sonolastic NP II.
- D. Medium Modulus Silicone Rubber Sealant: Silicone rubber based 1-part neutral cure elastomeric sealant with plus 50 percent to minus 50 percent movement complying with ASTM C920 and Fed. Spec. TT-S-001543, Class A, and recommended by manufacturer for joints.
 - 1. Location: Exterior joints subject to movement, NOT in contact with external insulation finishing system (EIFS).
 - 2. Acceptable Manufacturers and Product:
 - a. Dow Corning Corporation: 795 Building Sealant or DC 791.
 - b. Sonneborn, ChemRex Inc.: Sonolastic Omniseal or OmniPlus.
 - c. Tremco Construction Division: Spectrum 2.



- E. Foam Gasket Seal: Precompressed, impregnated open-cell foam sealant incorporating permanently elastic open cell polyurethane foam, manufacturer's standard impregnating agent, and pressure sensitive backing.
 - 1. Acceptable Manufacturers and Product:
 - a. Emseal Corporation: Emseal Greyflex.
 - b. Illbruck Inc.: Will-Seal 150.
 - c. York Manufacturing, Inc.: York-Seal 100.
- F. Foam Gasket Seal for Submerged Application: Precompressed, impregnated open-cell foam sealant incorporating permanently elastic open cell polyurethane foam, manufacturer's impregnating agent at higher levels than standard product, and pressure sensitive backing.
 - 1. Specially designed for use in submerge application.
 - 2. Acceptable Manufacturers and Product:
 - a. Emseal Corporation: Emseal.
 - b. Illbruck Inc.: Will-Seal 200.
 - c. York Manufacturing, Inc.: York-Seal 200.
- G. Splice Adhesive for Foam Gasket Seal: 1-part urethane wet sealant as recommended by gasket seal manufacturer.

2.2 ACCESSORIES

- A. Primer: Non-staining type, recommended by sealant manufacturer to suit application.
- B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.
- C. Joint Backing: Round foam rod compatible with sealant; ASTM D1056, sponge or expanded rubber; or ASTM D1667, closed cell PVC; oversized 30 to 50 % larger than joint width.
 - 1. Type: As recommended by manufacturer.
- D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify substrate surfaces and joint openings are ready to receive work.
- C. Verify joint backing and release tapes are compatible with sealant.

3.2 PREPARATION

- A. Remove loose materials and foreign matter impairing adhesion of sealant.
- B. Clean and prime joints.



- C. Perform preparation in accordance with ASTM C1193.
- D. Protect elements surrounding Work of this section from damage or disfiguration.

3.3 INSTALLATION

- A. Perform installation in accordance with ASTM C1193.
- B. Perform acoustical sealant application work in accordance with ASTM C919.
- C. Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer, except where specific dimensions are indicated.
- D. Install bond breaker where joint backing is not used.
- E. Install sealant free of air pockets, foreign embedded matter, ridges, and sags.
- F. Apply sealant within recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.
- G. Tool joints as detailed.
- H. Precompressed Foam Sealant: Do not stretch; avoid joints except at corners, ends, and intersections; install with face 3 to 6 mm below adjoining surface.
- I. Compression Gaskets: Avoid joints except at ends, corners, and intersections; seal joints with adhesive; install with face 3 to 6 mm below adjoining surface.

3.4 CLEANING

- A. General Requirements: Execution requirements for final cleaning.
- B. Clean adjacent soiled surfaces.

3.5 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Protect sealants until cured.

3.6 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 09220

PORTLAND CEMENT PLASTER

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes Portland cement plaster system.
- B. Related Sections:
 - 1. Division 3 - Concrete.
 - 2. Division 4 - Masonry.
 - 3. Division 5 - Metals.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM C91 - Standard Specification for Masonry Cement.
 - 2. ASTM C150 - Standard Specification for Portland Cement.
 - 3. ASTM C206 - Standard Specification for Finishing Hydrated Lime.
 - 4. ASTM C207 - Standard Specification for Hydrated Lime for Masonry Purposes.
 - 5. ASTM C665 - Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
 - 6. ASTM C847 - Standard Specification for Metal Lath.
 - 7. ASTM C897 - Standard Specification for Aggregate for Job-Mixed Portland Cement-Based Plasters.
 - 8. ASTM C926 - Standard Specification for Application of Portland Cement-Based Plaster.
 - 9. ASTM C932 - Standard Specification for Surface-Applied Bonding Agents for Exterior Plastering.
 - 10. ASTM C933 - Standard Specification for Welded Wire Lath.
 - 11. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete.
 - 12. ASTM C1002 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases.
 - 13. ASTM C1032 - Standard Specification for Woven Wire Plaster Base.
 - 14. ASTM C1063 - Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster.
 - 15. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
 - 16. ASTM C1328 - Standard Specification for Plastic (Stucco) Cement.
 - 17. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
- B. Federal Specification Unit:
 - 1. FS UU-B-790 - Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant).



- C. National Terrazzo and Mosaic Association:
 - 1. NTMA - Terrazzo Specifications Guide.
- D. Portland Cement Association:
 - 1. PCA - Portland Cement Plaster (Stucco) Manual.
- E. Underwriters Laboratories Inc.:
 - 1. UL - Fire Resistance Directory.
- F. Intertek Testing Services (Warnock Hersey Listed):
 - 1. WH - Certification Listings.

1.3 PERFORMANCE REQUIREMENTS

- A. Conform to ASTM E119 and applicable code for fire rated assemblies, and as follows:
 - 1. Fire Rated Partitions: Listed assembly by UL or WH.
 - 2. Fire Rated Ceilings Bulkheads and Interior Soffits: Listed assembly by UL or WH.
 - 3. Fire Rated Structural Column Framing: Listed assembly by UL or WH.
 - 4. Fire Rated Structural Beam Framing: Listed assembly by UL or WH.
- B. Fabricate vertical elements to limit finish surface to 1:360 deflection under lateral point load of 445 N.
- C. Fabricate horizontal elements to limit finish surface to 1:360 deflection under superimposed dead load and wind uplift loads.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data on plaster materials, characteristics and limitations of products specified.
- C. Samples: Submit two samples, size as directed, illustrating finish color and texture.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with ASTM C926 and PCA Portland Cement Plaster (Stucco) Manual.
- B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum five years documented experience.



1.7 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mock-up, size as directed by the Engineer, including exterior and interior wall and ceiling system illustrating surface finish.
- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.

1.8 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.9 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Exterior Plaster: Do not apply plaster when ambient temperature is less than 4°C.
- C. Interior Plaster: Do not apply cement plaster unless minimum temperature of 10°C has been and continues to be maintained in building for minimum 48 hours prior to plaster application, during application, and until cured.

PART 2 PRODUCTS

2.1 PORTLAND CEMENT PLASTER

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.

2.2 COMPONENTS:

- A. Plaster Materials:
 - 1. Cement: ASTM C150, Type I Portland cement.
 - 2. Aggregate: Natural sand, within the following sieve sizes and percentage retained limits:

<u>Sieve Size</u>	<u>Percent Retained</u>
4.75 mm	0
2.36 mm	0 to 5
1.18 mm	5 to 30
0.60 mm	30 to 65
0.30 mm	65 to 95
0.15 mm	90 to 100
 - 3. Water: Clean, fresh, potable and free of mineral or organic matter capable of affecting plaster.
 - 4. Bonding Agent: ASTM C932; type recommended for bonding plaster to concrete and concrete masonry surfaces.



5. Admixtures: Type as per manufacturer instructions.
 6. Glass Fibers: 13 mm nominal length; meeting requirements of ASTM C1116.
 7. Color Pigment: ASTM C979 mineral oxide or synthetic type, color as selected by the Engineer.
 8. Sand for finish coats shall be clean, graded silica sand, 100% passing a 30 mesh screen.
- B. Furring and Lathing:
1. Expanded Metal Lath: ASTM C847, galvanized, to suit application.
 2. Woven Wire Plaster Base: ASTM C1032, having 25 mm openings.
 3. Welded Wire Lath: ASTM C933.
 4. Backing Material: FS UU-B-790 Grade D.
 5. Casing and Corner Beads, and Base Screed: Formed sheet steel, depth governed by plaster thickness, maximum possible lengths, expanded metal or solid flanges, with square, bullnosed, or beveled edges; galvanized.
 6. Corner Mesh: Formed sheet steel, minimum 0.5 mm thick, perforated or expanded flanges shaped to permit complete embedding in plaster, minimum 50 mm size; galvanized.
 7. Strip Mesh: Expanded metal lath, minimum 0.5 mm thick, 50 mm wide x 600 mm long; galvanized.
 8. Control and Expansion Joint Accessories: Formed sheet steel, accordion profile, 50 mm expanded metal or solid flanges each side, galvanized.
 9. Anchorage: Tie wire, nails, and other metal supports, of type and size to suit application; to rigidly secure materials in place, galvanized.
 10. Fasteners: ASTM C1002, self drilling, self tapping screws.
 11. Polyethylene Sheet: Clear, 0.15 mm thick.
 12. Access Panels in Plaster on Metal Furring (If Any): Formed stainless steel type 316, one hour fire rating.
- C. Acoustic Accessories:
1. Resilient Channels: Formed steel, minimum 0.5 mm thick; face, profile and width as indicated on drawings, splicing permitted; galvanized.
 2. Acoustic Insulation: ASTM C665, friction fit type, unfaced; Thickness as per manufacturer's instructions.
 3. Acoustic Sealant: Non-hardening, non-skinning, for use with plaster system.

2.3 MIXES

- A. Except where hand-mixing of small batches is approved by the Engineer, mechanical mixers of an approved type shall be used for the mixing of plaster. Frozen, caked or lumped materials shall not be used.
- B. Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of plaster from previous mixes. Plaster shall be thoroughly mixed with the proper amount of water uniform in colour and consistency. Retempering will not be permitted and all plaster which has begun to stiffen shall be discarded.
- C. All tools, implements, vessels and surfaces shall at all time be kept scrupulously clean and strict precautions shall be taken to avoid the plasterer or other materials becoming contaminated by pieces of partially set material which would tend to retard or accelerate the setting time.



- D. Spartterdash Coat (Rasheh): 1 part Portland cement and maximum 2 parts of sand, proportioned by volume.
- E. Internal plaster shall be (1:3) composed of 475 kg of cement per m³ of sand. Internal plaster shall be 15 mm thick for walls and ceilings.
- F. External plaster shall be (1:3) composed of 475 kg of cement per m³ of sand. External plaster shall be 20 mm thick.
- G. Internal and external plasters shall be executed in one single coat work in addition to the spartterdash (Rasheh). If more than one coat is required, approved galvanized wire mesh reinforcement shall be used.
- H. Mix and proportion cement plaster in accordance with approved methodology.
- I. Add glass fibers to plaster at rate of 8.0 kg per cubic meter of plaster.
- J. Add admixtures as instructed by the manufacturer.
- K. Mix only as much plaster as can be used prior to initial set.
- L. Add color pigments to finish coat.
- M. Mix materials dry, to uniform color and consistency, before adding water.
- N. Protect mixtures from freezing, frost, contamination, and excessive evaporation.
- O. Do not retemper mixes after initial set has occurred.

2.4 READY MIX PLASTER

- A. For External Applications: Fiber reinforced cementitious ready mix plaster as produced by "Sodamco" or similar approved.
 - 1. Appearance: Grey powder.
 - 2. Grain Size: 0.02 to 1.5 mm.
 - 3. Composition: Portland cement, selected sand, fibers and additives.
 - 4. Wet Mix Life: Less than 1 hour.
 - 5. Compressive Strength: 10 MPa.
 - 6. Mix: 50 kg bag with 9 to 10 liters of clean water.
 - 7. Coat Thickness: 20 mm.
 - 8. Consumption: Around 2.0 kg/m²/1mm thickness.
- B. For Internal Applications: Cementitious ready mix plaster as produced by "Sodamco" or similar approved.
 - 1. Appearance: Grey powder.
 - 2. Grain Size: 0.02 to 1.5 mm.
 - 3. Composition: Portland cement, selected sand and additives.
 - 4. Wet Mix Life: Less than 1 hour.
 - 5. Mix: 50 kg bag with 7 to 8 liters of clean water.
 - 6. Coat Thickness: 15 mm.
 - 7. Consumption: Around 1.7 kg/m²/1mm thickness.



PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Masonry: Verify joints are cut flush and surface is ready to receive work of this section. Verify no bituminous or water repellent coatings exist on masonry surface.
- C. Concrete: Verify surfaces are flat, honeycomb and are filled flush, and surfaces are ready to receive work of this section. Verify no bituminous, water repellent, or form release agents exist on concrete surface that are detrimental to plaster bond.
- D. Metal Lath and Accessories: Verify lath is flat, secured to substrate, and joint and surface perimeter accessories are in place.
- E. Mechanical and Electrical: Verify services within surfaces to be plastered (walls, ceiling, etc.) have been tested and approved.

3.2 PREPARATION

- A. Dampen masonry surfaces to reduce excessive suction.
- B. Clean concrete surfaces of foreign matter. Clean surfaces using acid solutions, solvents, or detergents. Wash surfaces with clean water.
- C. Roughen smooth concrete surfaces and apply bonding agent.
- D. Galvanized wiremesh reinforcement shall be provided wherever blockwalls abut against concrete columns, beams or slabs, and plaster finish is required to continue over both blockwork and concrete surfaces. The galvanized wiremesh reinforcement shall consist of 20 cm wide strips and shall cover the whole length of the joint, horizontally as well as vertically and shall be securely nailed, plugged or stapled in place to both surfaces at intervals not exceeding 40 cm at both edges.
- E. Plastering shall not be commenced until all mechanical and electrical services, conduits, pipes and fixtures have been installed complete and tested.
- F. All walls shall be wetted immediately prior to applying the first spatterdash coat (Rasheh) to provide key for subsequent coats.

3.3 EXISTING WORK

- A. Extend existing Portland cement plaster installations using materials and methods as specified.
- B. Repair existing damaged Portland cement plaster which remains or to be remodeled.



3.4 INSTALLATION

- A. Installation of Lathing Materials:
 - 1. Apply one or two layers of Grade D building paper over substrate; lap edges 50 mm minimum. Fasten in place.
 - 2. Install metal lath in accordance with ASTM C1063.
- B. Installation of Accessories:
 - 1. Install accessories in accordance with ASTM C1063.
 - 2. Place corner bead at external wall corners; fasten at outer edges of lath only.
 - 3. Place strip mesh diagonally at corners of lathed openings. Secure rigidly in place.
 - 4. Place casing beads at terminations of plaster finish. Butt and align ends. Secure rigidly in place.
 - 5. Install door and glazed frames plumb and level in opening. Secure rigidly in place.
 - 6. Position to provide convenient access to concealed work requiring access.
- C. Control and Expansion Joints:
 - 1. Install interior control and expansion joints as indicated on Drawings.
 - 2. Install exterior contraction joints after initial set, scribed as indicated on Drawings by cutting through 2/3 of cement plaster depth, neatly, in straight lines.
 - 3. For horizontal exterior surfaces, install control and expansion joints as indicated on Drawings.
 - 4. For vertical exterior surfaces install control and expansion joints as indicated on Drawings.
 - 5. Establish control and expansion joints with specified joint device.
- D. Plastering:
 - 1. Plaster shall be thoroughly mixed with the proper amount of water until uniform in colour and consistency. Retempering will not be permitted and all plaster which has begun to stiffen shall be discarded.
 - 2. All plastering shall be executed in a neat workmanlike manner and corners shall be true, straight and plumb.
 - 3. All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to avoid the plaster or other materials becoming contaminated by pieces of partially set materials which would tend to retard or accelerate the setting time.
 - 4. The temperature before, during and after application of plaster shall be uniformly maintained above 12°C. The heat shall be well distributed in all areas, and concentration or irregular heat on plaster surfaces shall be prevented.
 - 5. Ventilation shall be provided to properly dry the plaster during and subsequent to its application. Plaster shall be prevented from too-rapid drying.
 - 6. All ingredients entering the several mixes shall be proportioned and measured by means of calibrated boxes or containers of such nature that the quantities can be accurately checked at any time. Ingredients shall be thoroughly mixed and then cleaned from the mixer and tools after each mix.



7. Plaster shall be rodded and straight-edged to uniform thickness in true planes flush to the required surface and flush with outlet boxes, and similar details and steel-troweled smooth and level with sharp, straight arises and true angles. Plaster shall be free from laps, cracks, trowels marks, or other structural defects or surface imperfections.
 8. Where plaster finish is flush with adjoining surface or where tooled joint is indicated on the drawings, the plaster shall be grooved back with smallest available edging tool, to control any cracking at these points.
 9. At doors and frames and other openings, all plaster shall be keyed in, except that across head of openings and 12 inches down each side plaster shall be cut free of frame, or grounds with edge of trowel, after stiffening but before setting, to allow for expansion.
 10. All pressed metal door frames in walls shall be grouted full with Portland cement fine concrete after being completely anchored in place and prior to application of plaster. Rake grout to allow plaster to enter jamb.
 11. Apply the spatterdash coat (Rasheh) and allow to dry before rendering is commenced.
 12. Moist cure each coat. Apply successive coat immediately following initial set of scratch coat.
 13. After curing, dampen previous coat prior to applying finish coat.
 14. Apply finish coat to indicated color and texture.
 15. Plumb, square and level.
 16. Avoid excessive working of surface. Delay troweling as long as possible to avoid drawing excess fines to surface.
 17. Moist cure finish coat for minimum period of 48 hours.
- E. Waterproof Plaster to External Surfaces:
1. All surfaces to be plastered shall be clean and free from dust, grease, loose or projecting mortar and all traces of salts and are to be thoroughly sprayed with water but all free water shall be allowed to disappear from the surface before the plaster is applied.
 2. Efflorescence shall be brushed off and all dust and foreign matter removed. All waterproof plastering shall be in two coats and shall contain 475 kg of cement per one meter cube of sand mixed with an approved waterproofing admixture compound and applied in accordance with manufacturer's instructions and shall be applied and allowed to dry before rendering is commenced. All walls shall be wetted immediately prior to applying the first coat of rendering and this shall be allowed to thoroughly dry out before the next coat is applied.

3.5 ERECTION TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation from Flat Surface: 3 mm in 3 m, non-cumulative.

3.6 ADJUSTING

- A. General Requirements: Execution requirements for testing, adjusting and balancing.



- B. Remove damaged or defective plaster by cutting and replace with specified materials to match adjacent plaster.
- C. Fog coat non-uniform or discolored plaster with finish coat materials spray applied to entire finish coat surface.

3.7 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 09626

SAND CEMENT SCREED FLOORING

PART 1 GENERAL

1.1 SUMMARY

- A. This section specifies architectural sand cement screed casted as floor finish, or substrate to other floor finishes.

1.2 REFERENCES

- A. American Concrete Institute (ACI):
1. ACI 308 - Standard Practice for Curing Concrete.
 2. ACI 318 - Building Code Requirements for Reinforced Concrete.
 3. ACI 347 - Recommended Practice for Concrete formwork.
- B. American Standards for Testing and Materials (ASTM):
1. ASTM C94 - Ready-Mixed Concrete.
 2. ASTM C150 - Portland Cement.
 3. ASTM C190 - Test Method for Tensile strength of Hydraulic Cement Mortars.
 4. ASTM C256 - Test Method for Flexural strength of Hydraulic Cement Mortars.
 5. ASTM C1439 - Test Method for Compressive strength of Hydraulic Cement Mortars.
- C. BS EN Standards:
1. BS EN 206-1 - Concrete, specification, performance, production and conformity.
 2. BS 8204 - Code of Practice for Screeds, Bases and In-Situ Floorings.
 3. BS EN 13318 - Screed material and floor screeds, definitions.
- D. Code of Practice:
1. CP 202 - Code of Practice for Tile Flooring and Slab Flooring.
 2. CP 203 - Code of Practice for Sheet and Tile Flooring.
 3. CP 204 - Code of Practice for In-Situ Floor Finishes.
- E. DIN Standards:
1. DIN 18353 - Contract Procedures for Building Works - Part C: General Technical Specifications for Building Works - Floor Screed Works.
 2. DIN 18560 - Floor Screeds in Building Construction.
- F. All applicable local codes, regulations, etc. of Authorities having Jurisdiction.

1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.



- B. Product Data: Submit data on screed hardener, sealer, curing compounds and slip resistant treatment, compatibilities, and limitations.
- C. Design Data:
 - 1. Submit mix design.
 - 2. Submit separate mix designs when admixtures are required for the following:
 - a. Hot and cold weather concrete work.
 - b. Air entrained concrete work.
 - 3. Identify mix ingredients and proportions, including admixtures.

1.4 QUALITY ASSURANCE

- A. Perform work in accordance with Referenced Standards.
- B. Acquire cement and aggregate from same source for all work.
- C. Use only 1 brand of cement and admixtures unless otherwise approved in writing by the Engineer.
- D. Provide the Engineer with delivery ticket for each load of screed.

1.5 REGULATORY REQUIREMENTS

- A. Comply with all requirements of applicable Standards and Codes.

PART 2 PRODUCTS

2.1 SAND CEMENT SCREED

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
 - 1. Approved Manufacturers: Refer to List of Manufacturers (Annex 1).

2.2 MATERIALS

- A. Cement: To ASTM C150, type I, Portland cement, unless noted otherwise.
- B. Aggregate: To ASTM C33.
- C. Reinforcement: 8 mm thick welded wire mesh.
- D. Water: Clear, clean, potable water complying with BS EN 1008.

2.3 CONCRETE MIX

- A. Screed Type:
 - 1. Screed as Substrate for Other Floor Finishes: Lean concrete screed of at least 24 MPa on cylinder (30 MPa on cube), with a minimum thickness of 50mm.
 - 2. Screed as Floor Finish: Bonded lean concrete screed, crack free and shrink free with strength of at least 30 MPa on cylinder (38 MPa on cube), 100mm thick unless otherwise shown on drawings.



2.4 REINFORCEMENT

- A. For Storage Areas, Technical Rooms and any Other Equipment Areas: At least 8mm thick welded wire mesh, unless otherwise shown on drawings.

2.5 JOINT FILLERS

- A. Refer to Section 03300 and Section 07900.

2.6 CURING MATERIALS

- A. Curing material shall be fresh potable water complying with BS EN 1008.

PART 3 EXECUTION

3.1 MIXING

- A. Plant Batched and Transit Mixed:
 - 1. Batch at a central plant in compliance with ASTM C94.
- B. Hand Mixed:
 - 1. Hand mixing on site is not permitted.

3.2 SCREED PLACEMENT

- A. Notify Engineer minimum 24 hours prior to placement.
- B. Convey screed from a mixer to the forms as near final position as practical in a manner which will prevent segregation or loss of materials.
- C. Place screed in bays of 3m to 4m wide.
- D. Immediately after placing, thoroughly compact and level screed.
- E. Do not drop screed freely from higher than 4 feet above the surface of being poured.
- F. Power float screed surfaces which are indicated to be exposed and all surfaces which are directed by the Engineer:
 - 1. Consolidate surface with power driven floats as soon as topping can support equipment and operator.
 - 2. Re-straighten, cut down high spots, and fill low spots.
 - 3. Repeat float passes and re-straightening until surface is smooth and uniform in texture, and to the satisfaction of the Engineer.

3.3 CURING

- A. Commence curing and protection of screed immediately after placing, as instructed by the Engineer. Curing shall be done by potable water only.



3.4 CONCRETE REPAIR

- A. For any repair of sand cement screed, use products complying with BS EN 1504 (1-9) as applicable.

3.5 CLEANING AND PROTECTION

- A. General Requirements: Execution requirements for final cleaning.
- B. Clean and protect all surfaces on which sand cement screed was scheduled.
- C. Do not permit traffic over unprotected floor surface.

3.6 SCHEDULES

- A. As indicated on drawings and where directed by the Engineer.

END OF SECTION



SECTION 09900

PAINTS AND COATINGS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes surface preparation and field application of paints, stains, varnishes, and other coatings.
- B. Related Sections:
 - 1. Division 5 - Metals: Shop primed metal items.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM D16 - Standard Terminology Relating to Paint, Varnish, Lacquer, and Related Products.
 - 2. ASTM D4442 - Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials.
- B. Painting and Decorating Contractors of America:
 - 1. PDCA - Architectural Painting Specification Manual.
- C. SSPC: The Society for Protective Coatings:
 - 1. SSPC - Steel Structures Painting Manual.

1.3 DEFINITIONS

- A. Conform to ASTM D16 for interpretation of terms used in this section.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data on finishing products and special coating.
- C. Samples:
 - 1. Submit two paper chip samples each 300 x 300 mm, illustrating color range and textures available for each surface finishing product scheduled.
 - 2. Submit two painted samples, illustrating selected colors and textures for each color and system selected with specified coats cascaded.
- D. Manufacturer's Installation Instructions: Submit special surface preparation procedures, and substrate conditions requiring special attention.

1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.



- B. Operation and Maintenance Data: Submit data on cleaning, touch-up, and repair of painted and coated surfaces.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum ten years documented experience.
- B. Applicator: Company specializing in performing work of this section with minimum five years documented experience.

1.7 MOCKUP

- A. General Requirements: Quality requirements for mock-up.
- B. Construct mockup panel, size as directed by the Engineer, illustrating special coating color, texture, and finish.
- C. Construct door and frame assembly illustrating painting, stain and varnish, coating color, texture, and finish.
- D. Locate where directed by the Engineer.
- E. Remove mockup when directed by the Engineer.

1.8 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.9 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for product storage and handling.
- B. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.
- C. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- D. Storage of Paint Materials: Store at minimum ambient temperature of 7°C and maximum ambient temperature of 32°C in ventilated area, and as required by manufacturer's instructions.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Do not apply materials when surface and ambient temperatures are outside temperature ranges required by paint product manufacturer.



- C. Do not apply exterior coatings during rain/snow, or when relative humidity or moisture content of surfaces exceed those required by paint product manufacturer.
- D. Minimum Application Temperatures for Latex Paints: 7°C for interiors; 10°C for exterior, unless required otherwise by manufacturer's instructions.
- E. Minimum Application Temperature for Varnish Finishes: 18°C for interior or exterior, unless required otherwise by manufacturer's instructions.
- F. Provide lighting level of 860 lx measured mid-height at substrate surface.

1.11 SEQUENCING

- A. General Requirements: Requirements for Work sequence.
- B. Sequence application to the following:
 - 1. Do not apply finish coats until paintable sealant is applied.
 - 2. Back prime wood trim before installation of trim.

1.12 WARRANTY

- A. General Requirements: Execution requirements for product warranties and bonds.
- B. Furnish ten year manufacturer warranty for paints and coatings.

1.13 EXTRA MATERIALS

- A. General Requirements: Execution requirements for spare parts and maintenance products.
- B. Supply 4 liters of each color, type and surface texture; store where directed.
- C. Label each container with color, type, texture and room locations in addition to manufacturer's label.

PART 2 PRODUCTS

2.1 MANUFACTURER

- A. Paint, Transparent Finishes, Stain, Primer Sealers, Block Filler, and Field Catalyzed Coatings Manufacturers: Any internationally recognized manufacturers having an official technical agreement to conformity with standards for the products.
- B. Furnish materials as specified, as shown on drawings and to Engineer's satisfaction.

2.2 COMPONENTS

- A. Coatings: Ready mixed, except field catalyzed coatings. Process pigments to a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating; prepare coatings for good flow and brushing properties, capable of drying or curing, and free of streaks or sags.



- B. Use products of the same manufacturer for succeeding coats. Where primer is shop applied to steel, subsequent coats may be the product of another manufacturer provided the coatings are mutually compatible.
- C. Colors, textures and degree of luster shall be as selected by the Engineer. Tint prime and undercoats approximately to the shade of the final coat but with sufficient variation to distinguish them from the preceding coat. Proprietary names used to designate colors or materials, are not intended to imply that products named are required, or to exclude equal products of other manufacturers.
- D. Colors of finishes shall not necessarily be manufacturer's stock colors. All materials for finishing coats shall be factory mixed and shall be of a standard quality equal to that of the standard colors of the material specified.
- E. Specular Gloss Range:
1. Ranges determined in accordance with ASTM D523:

<u>Sheen</u>	<u>Geometry / Degree</u>	<u>Gloss / Range</u>
Flat	85	Below 15
Eggshell	60	5 to 20
Semi-Gloss	60	30 to 65
Gloss	60	Over 65
 2. In locations where ambient temperature and humidity conditions encourage the ready formation of mildew, use paints with additional mildew inhibitive agent incorporate during the manufacturing process, of type and in concentration recommended by the paint manufacturer to withstand such mildew formation.
- F. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials not specifically indicated but required to achieve the finishes specified.
- G. Patching Materials: Latex filler.
- H. Fastener Head Cover Materials: Latex filler.
- I. Putty:
1. Putty shall comply with the following standards:
 - a. ASTM C321-83 and ASTM D2486-79
 - b. BS 2750, sound reduction.
 - c. BS 1191, 4551, 5270, 5492 and 6214 C and E.
 - d. NF T 30-606 and 30-608
 - e. US Federal TT C-555, textured coating.
 2. Putty material shall be as manufactured by "alltek", "TouPret" or approved equal.
 3. Putty shall be applied in four coats unless otherwise stated.

2.3 INTUMESCENT PAINT

- A. Approved Manufacturer: FIREFREE Coatings - Inc., Sherwin-Williams, International Paint - LLC, or similar approved.



- B. Types of Intumescent Coating Systems:
 - 1. Thin-Film Intumescent Coatings: Solvent or water based, for internal use
 - 2. Thick-Film Intumescent Coatings (Two component epoxy): epoxy based, for external and aggressive environment use.
- C. Thickness of Intumescent Coating Systems (Primer, basecoat & sealer/decorative coat): As per manufacturer's recommendations to reach the required Fire Resistance Period/Fire Resistance Level]
- D. Material Characteristics:
 - 1. Surface Burning Characteristics: Class A (ASTM E-84)
 - 2. Quality Control Requirements: FM approved and/or UL listed

2.4 HIGH-PERFORMANCE COATINGS COMPONENTS

- A. General: Furnish complete multi-coat systems formulated and recommended by manufacturer for applications indicated, in thicknesses indicated; number of coats specified does not include primer or filler coat.
 - 1. Lead content: None.
 - 2. Chromium content, as zinc chromate or strontium chromate: None.
 - 3. Maximum VOC content: As required by applicable regulations.
 - 4. Colors: As selected from manufacturer's standard colors or as per Drawings.
- B. Epoxy Coating: Polyamide, or polyester epoxy; complying with MIL C-22750; gloss, semi-gloss, or eggshell finish.
 - 1. Percentage of solids by volume: To manufacturer's recommendations to suit project requirements.
 - 2. Number of Coats and Dry Film Thickness per Coat: Two coats, 150 microns each, unless otherwise shown on drawings.
 - 3. Comply with performance requirements of MIL C-22750
- C. Epoxy Floor Coating: Two-part, polyamide or polyester epoxy, fuel oil resistant, non-skid finish.
 - 1. Percentage of Solids by Volume: To manufacturer's recommendations to suit project requirements.
 - 2. Number of Coats and Dry Film Thickness per Coat:
 - a. For Parking and Traffic Circulation Areas: Three coats, 250 microns each, without aggregates.
 - b. For Ramp: Three coats, 250 microns each, with aggregates.
 - c. Others: Two coats, 200 microns each, without aggregates.
 - 3. Comply with performance requirements of MIL C-22750.
- D. Polyurethane Coating: Two-part, aliphatic moisture-curing polyurethane, gloss, semi-gloss, or eggshell finish.
 - 1. Percentage of Solids by Volume: To manufacturer's recommendations to suit project requirements.
 - 2. Number of Coats and Dry Film Thickness per Coat: Two coats, 150 microns each, unless otherwise shown on drawings.
 - 3. Comply with performance requirements specified above for severe exposure.



- E. Polyurethane Floor Coating: Two-part, aliphatic polyurethane, non-skid finish.
 - 1. Percentage of Solids by Volume: To manufacturer's recommendations to suit project requirements.
 - 2. Number of Coats and Dry Film Thickness per Coat: Unless otherwise shown on drawings:
 - a. For Parking and Traffic Circulation Areas: Three coats, 250 microns each, without aggregates.
 - b. For Ramp: Three coats, 250 microns each, with aggregates.
 - c. Others: Two coats, 200 microns each, without aggregates.
 - 3. Comply with performance requirements specified above for severe exposure.
- F. Primers: As recommended by coating manufacturer for specific substrate with a minimum of 50 microns dry film thickness.
- G. Shellac: Pure, white type.

2.5 FIBER REINFORCED EPOXY COATING/LINING FOR SEWER STRUCTURES

- A. One layer of approved coal tar pitch epoxy coating, 200 microns thick, as per manufacturer's instructions.
- B. One layer of approved fiberglass mesh-reinforcement as per manufacturer's instructions, thickness ranging from 3 to 4 mm.
- C. Another two layers of the approved coal tar pitch epoxy coating, 200 microns thick each, as per manufacturer's instructions.

PART 3 EXECUTION

3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify surfaces and substrate conditions are ready to receive Work as instructed by product manufacturer.
- C. Examine surfaces scheduled to be finished prior to commencement of work. Report conditions capable of affecting proper application.
- D. Test shop applied primer for compatibility with subsequent cover materials.
- E. Measure moisture content of surfaces using electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following values:
 - 1. Plaster and Gypsum Boards: 12 percent.
 - 2. Masonry, Concrete and Concrete Unit Masonry: 12 percent.
 - 3. Wood: 15 percent, measured in accordance with ASTM D 4442.
 - 4. Concrete Floors: 8 percent.



3.2 PREPARATION

- A. Surface Appurtenances: Remove or mask electrical plates, hardware, light fixture trim, escutcheons, and fittings prior to preparing surfaces or finishing.
- B. Surfaces: Correct defects and clean surfaces capable of affecting work of this section. Remove or repair existing coatings exhibiting surface defects.
- C. Marks: Seal with shellac those which may bleed through surface finishes.
- D. Impervious Surfaces: Remove mildew by scrubbing with solution of tetra-sodium or tri-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.
- E. Aluminum Surfaces Scheduled for Paint Finish: Remove surface contamination by steam or high pressure water. Remove oxidation with acid etch and solvent washing. Apply etching primer immediately following cleaning.
- F. Asphalt, Creosote, or Bituminous Surfaces Scheduled for Paint Finish: Remove foreign particles to permit adhesion of finishing materials. Apply latex based, or compatible sealer or primer.
- G. Insulated Coverings: Remove dirt, grease, and oil from canvas and cotton.
- H. Concrete Floors: Remove contaminations, acid etch and rinse floors with clear water. Verify required acid-alkali balance is achieved. Allow to dry.
- I. Copper Surfaces Scheduled for Natural Oxidized Finish: Remove contamination by applying oxidizing solution of copper acetate and ammonium chloride in acetic acid. Rub on repeatedly for required effect. Once attained, rinse surfaces with clear water and allow to dry.
- J. Copper Surfaces Scheduled for Paint Finish: Remove contamination by steam, high pressure water, or solvent washing. Clean and immediately apply vinyl etch primer.
- K. Gypsum Board Surfaces: Fill minor defects with filler compound. Spot prime defects after repair.
- L. Galvanized Surfaces: Remove surface contamination and oils and wash with solvent. Apply coat of etching primer.
- M. Concrete and Unit Masonry Surfaces Scheduled to Receive Paint Finish: Remove dirt, loose mortar, scale, salt or alkali powder, and other foreign matter. Remove oil and grease with solution of tri-sodium phosphate; rinse well and allow to dry. Remove stains caused by weathering of corroding metals with solution of sodium meta-silicate after thoroughly wetting with water. Allow for drying.
 - 1. Exposed concrete surfaces shall be clean and without any holes, lips, angular ridges, unstable sandy or granular areas, and the like, all to the satisfaction of the Engineer (Holes shall be flush filled. Lips, aggressive ridges, projections, etc. shall be flushed by grinding).



- N. Plaster Surfaces: Fill hairline cracks, small holes, and imperfections with latex patching plaster. Make smooth and flush with adjacent surfaces. Wash and neutralize high alkali surfaces.
- O. Uncoated Steel and Iron Surfaces: Remove grease, mill scale, weld splatter, dirt, and rust. Where heavy coatings of scale are evident, remove by hand or power tool wire brushing or sandblasting; clean by washing with solvent. Apply treatment of phosphoric acid solution, ensuring weld joints, bolts, and nuts are similarly cleaned. Spot prime paint after repairs.
- P. Shop Primed Steel Surfaces: Sand and scrape to remove loose primer and rust. Feather edges to make touch-up patches inconspicuous. Clean surfaces with solvent. Prime bare steel surfaces. Prime metal items including shop primed items.
- Q. Interior Wood Items Scheduled to Receive Paint Finish: Wipe off dust and grit prior to priming. Seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after primer has dried; sand between coats.
- R. Interior Wood Items Scheduled to Receive Transparent Finish: Wipe off dust and grit prior to sealing, seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after sealer has dried; sand lightly between coats.
- S. Exterior Wood Scheduled to Receive Paint Finish: Remove dust, grit, and foreign matter. Seal knots, pitch streaks, and sappy sections. Fill nail holes with tinted exterior paintable caulking compound after prime coat has been applied.
- T. Exterior Wood Scheduled to Receive Transparent Finish: Remove dust, grit, and foreign matter; seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes with tinted exterior caulking compound after sealer has been applied.
- U. Glue-Laminated Wood: Prior to finishing, wash surfaces with solvent, remove grease and dirt.
- V. Wood Doors Scheduled for Painting: Seal wood door top and bottom edge surfaces with clear sealer or tinted primer.
- W. Metal Doors Scheduled for Painting: Prime metal door top and bottom edge surfaces.

3.3 EXISTING WORK

- A. Extend existing paint and coatings installations using materials and methods compatible with existing installations and as specified.

3.4 APPLICATION

- A. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.
- B. Apply each coat to uniform appearance. Apply each coat of paint slightly darker than preceding coat unless specified otherwise.
- C. Sand wood and metal surfaces lightly between coats to achieve required finish.



- D. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.
- E. Where clear finishes are required, tint fillers to match wood. Work fillers into grain before set. Wipe excess from surface.
- F. Prime concealed surfaces of interior and exterior woodwork with primer paint.
- G. Prime concealed surfaces of interior wood surfaces scheduled to receive stain or varnish finish with gloss varnish reduced 25 percent with thinner.
- H. Finishing Mechanical and Electrical Equipment:
 - 1. Refer to applicable codes and standards for schedule of color coding and identification banding of mechanical and electrical equipment, duct, piping, conduit, etc.
 - 2. Paint shop primed equipment.
 - 3. Remove unfinished louvers, grilles, covers, and access panels on mechanical and electrical components and paint separately.
 - 4. Prime and paint insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports, except where items are shop finished.
 - 5. Paint interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with one coat of flat black paint to visible surfaces. Paint dampers exposed behind louvers, grilles, and convector and baseboard cabinets to match face panels.
 - 6. Paint exposed conduit and electrical equipment occurring in finished areas.
 - 7. Paint both sides and edges of plywood backboards for electrical and telephone equipment before installing equipment.
 - 8. Color code equipment, piping, conduit and exposed duct work in accordance with requirements indicated or color schedule. Color band and identify with flow arrows, names and numbering.
 - 9. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.
- I. Install Work as specified, as shown on drawings, in accordance with manufacturer's instructions, and to the satisfaction of the Engineer.

3.5 INSTALLATION - FIBER REINFORCED EPOXY COATING/LINING

- A. Prepare the surfaces including sandblasting and air cleaning.
- B. Apply one layer of an approved coal tar pitch epoxy coating, 200 microns thick, as per manufacturer's recommendations.
- C. Place one layer of approved fiberglass reinforcements before the applied epoxy coating is completely dry, as per manufacturer's recommendations.
- D. Apply another two layers of the approved coal tar pitch epoxy coating, 200 microns thick each.



3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Inspect and test questionable coated areas in accordance with applicable code.

3.7 CLEANING

- A. General Requirements: Execution requirements for final cleaning.
- B. Collect waste material which may constitute fire hazard, place in closed metal containers, and remove daily from site.

3.8 SCHEDULES - SHOP PRIMED ITEMS FOR SITE FINISHING

- A. Shop primed items for site finishing are stated under Division 5.

3.9 SCHEDULES - EXTERIOR SURFACES

- A. Wood - Painted (Opaque):
 - 1. One coat of latex or alkyd primer sealer.
 - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- B. Wood - Transparent:
 - 1. Two coats of stain.
- C. Wood - Shingles and Shakes:
 - 1. One coat of stain or clear sealer.
 - 2. Two coats of clear sealer.
- D. Glue-Laminated Wood and Wood Timber Members:
 - 1. One coat of stain or sealer.
 - 2. Two coats of varnish, gloss or semi-gloss.
- E. Pavement Markings:
 - 1. Two coats of thermoplastic reflectorized paint, yellow or white.
- F. Concrete, Concrete Block, Restored Masonry and Cement Plaster:
 - 1. One coat of primer sealer latex or alkyd.
 - 2. Two coats of latex or alkyd, flat.
- G. Gypsum Board and Cement Plaster Soffits:
 - 1. One coat of primer sealer latex or alkyd.
 - 2. Two coats of latex or alkyd, flat.
- H. Structural Steelwork: Refer to individual specification sections of Division 5.
- I. Architectural Steel - Unprimed:
 - 1. One coat of latex or alkyd primer.
 - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.



- J. Architectural Steel - Shop Primed:
 - 1. Touch-up with zinc chromate or zinc rich primer.
 - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- K. Architectural Steel - Galvanized:
 - 1. One coat galvanized primer.
 - 2. One mordant coat.
 - 3. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- L. Aluminum - Mill Finish:
 - 1. One coat etching primer.
 - 2. Two coats of alkyd enamel, gloss.
- M. Copper:
 - 1. One coat etching primer.
 - 2. Two coats of alkyd enamel, gloss.

3.10 SCHEDULES - INTERIOR SURFACES

- A. Wood - Painted:
 - 1. One coat of latex or alkyd prime sealer.
 - 2. Two coats of alkyd or latex enamel, gloss, semi-gloss, eggshell or flat.
- B. Wood - Intumescent Coating:
 - 1. One coat of prime sealer.
 - 2. Two coats of intumescent coating.
- C. Wood - Transparent:
 - 1. Filler coat (for open grained wood only).
 - 2. Two coats of stain.
 - 3. One coat sealer.
 - 4. Two coats of varnish, gloss, satin or flat.
- D. Cabinet Interior:
 - 1. One coat of latex or alkyd prime sealer.
 - 2. One coat of alkyd or latex enamel, semi-gloss or flat.
- E. Glue-Laminated Wood and Wood Timber Members:
 - 1. One coat of stain or sealer.
 - 2. Two coats of varnish, gloss, satin or flat.
- F. Concrete, Concrete Block, Restored Masonry and Cement Plaster:
 - 1. One coat of primer sealer latex or alkyd.
 - 2. Two coats of latex or alkyd, flat or semi-gloss.
- G. Structural Steelwork: Refer to individual specification sections of Division 5.
- H. Architectural Steel - Unprimed:
 - 1. One coat of alkyd or latex primer.
 - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.



- I. Architectural Steel - Primed:
 - 1. Touch-up with alkyd or latex primer.
 - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- J. Architectural Steel - Galvanized:
 - 1. One coat galvanized primer.
 - 2. One mordant coat.
 - 3. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- K. Aluminum - Mill Finish:
 - 1. One coat etching primer.
 - 2. Two coats of alkyd enamel, gloss.
- L. Concrete Floors:
 - 1. One coat of alkali resistant or catalyzed epoxy primer.
 - 2. Two coats of alkyd floor enamel or catalyzed epoxy enamel, gloss.
- M. Gypsum Board and Plaster Walls and Ceiling:
 - 1. One coat of primer sealer latex or alkyd.
 - 2. Two coats of alkyd, latex or latex acrylic enamel or emulsion, gloss, semi-gloss, eggshell or flat.
- N. Wall Surfaces Under Vinyl Wall Covering:
 - 1. Two coats of alkyd primer sealer.
- O. Fire Retardant Finish:
 - 1. One coat of fire retardant primer.
 - 2. Two coats of fire retardant finish, gloss.
 - 3. Flame and smoke rating of 25/50.
- P. Insulated Coverings - Canvas and Cotton:
 - 1. One coat of alkyd primer sealer.
 - 2. Two coats of alkyd enamel, gloss, semi-gloss, eggshell or flat.

3.11 SCHEDULES - COLORS

- A. As indicated on drawings and/or as selected by the Engineer from manufacturer's range and samples.

END OF SECTION



Annex 1

Landfill Leachate Management Systems

Annex 1 - Landfill Leachate Management Systems

Technical and Performance Specifications

1. Leachate Collection and Drainage

The Contractor shall supply and install / construct a leachate collection (drainage) system including leachate collection pipes, collection sumps or tanks, and leachate pumping sets.

The leachate collection system shall be designed to minimize the head of leachate above the liner. The leachate head is a function of leachate generation, bottom slope, pipe spacing, and hydraulic conductivity of the drainage blanket.

- Basal shape

The base of cells shall be sloped to facilitate gravitational flow of leachate to leachate collection sumps. The following shall be considered:

- Minimum fall of 1.5-2% towards leachate collection sump shall be ensured. This gradient also promotes self-cleansing and reduces blockages in the leachate collection pipe(s); and
- Gradient towards the main leachate collection pipe(s) shall, at minimum, be 1%.

- Drainage Layer (sand or gravel)

The Drainage Layer shall consider the following:

- Thickness of 500 mm with minimum hydraulic conductivity of 1×10^{-3} m/sec;
- Rounded drainage media, pre-washed, non-calcareous stone (less than 10% CaCO_3);
- Particle size compatible with the proposed geo-membrane.
- Drainage Layer of documented durability and mechanical strength proportionate with the proposed loading; and
- Standard aggregate tests (e.g. Slake Durability Test BS882, Acid Immersion Test, Magnesium Sulfate Soundness Test).

- Leachate Collection/Drainage Pipes

Knowing that the drainage layer piping is the component that is considered the most vulnerable to compressive strength failure, the proper design of leachate collection pipes shall consider the following three main conditions:

- Required capacity and pipe spacing;

- Pipe size and maximum slope; and
- Structural strength of the pipe.

Leachate collection/drainage pipes shall, at minimum, meet the following requirements:

- A network of perforated smooth bore, minimum diameter of 200 mm (high density polyethylene, or polypropylene) laid to a self-cleansing gradient;
- Intake area of at least 0.01m²/m length of pipe;
- Crush strength shall be equal to the waste loading and operating equipment; and shall not be vulnerable to chemical attack by the leachate.

Leachate collection/drainage pipe spacing may be determined by the Mound model. In the Mound Model, the maximum height of fluid between two parallel perforated drainage pipes is equal to (U.S. EPA, 1989):

$$h_{\max} = \frac{L}{2} \sqrt{\frac{1}{c} \left[\frac{\tan^2 \alpha}{c} + 1 - \frac{\tan^2 \alpha}{c} \sqrt{\tan^2 \alpha + c} \right]}$$

Where:

h_{\max} = maximum allowable head on the liner

$c = q/K$

q = inflow rate

K = permeability

α = slope

The 2 unknowns in the equation are:

L = distance between the pipes and

c = amount of leachate.

The estimated amount of leachate generated can be obtained from the water balance calculations. The equation can then be solved to calculate the spacing of pipes.

During the early stages of leachate drainage pipe installation, protection is considered of great significance given that the piping system is most likely to be prone to damages. As such, it is advised that the first 2 meters of waste, free of bulky or sharp objects, are left un compacted above the drainage blanket. This will not only protect it from equipment damage but also will enhance drainage in the lower regions of the waste and provide extra filtering for suspended material being transported by leachate.

2. Leachate Removal and Pumping

Leachate can be removed/pumped from the landfill through leachate collection sumps or via a leachate collection header pipe system. The Contractor shall consider either one of the following leachate removal systems:

- A leachate collection sump or tank with a manhole extension rising vertically through the waste and final capping system. The sump is made either in situ or prefabricated off site. The vertical riser is either a concrete or plastic standpipe. It is extended as the waste is placed in the facility; or
- A leachate collection sump or tank with a solid wall pipe riser coming up the side slope where it eventually penetrates the final capping system.

- Liner Penetration

Penetration of the basal liner system shall be avoided where possible. A high degree of care shall be exercised by the Contractor in both the design and construction of the penetration. The penetration shall be designed and constructed in a manner that allows nondestructive quality control testing of the seal between the pipe and the geo-membrane liner.

- Sumps

Sumps are located at low points in cells to allow gravitational drainage of leachate. Leachate is removed from the sumps by pumping. In the past, low volume sumps have been constructed successfully from reinforced concrete pipe on a concrete footing (typically minimum 1m diameter). More recently high density polyethylene pipes have been used, welded to a thick HDPE baseplate using a series of supporting webs. The minimum size shall be approximately 300 mm to facilitate pump insertion if necessary. These structures (HDPE) may be suitable for replacing the concrete components of the sump and have the advantage of being lighter in weight.

- Vertical Chambers

Vertical leachate collection chambers shall be surrounded by a permeable drainage media, not deposited wastes, to assist in vertical percolation of leachate to the chamber. The Contractor shall give consideration to installing telescopic HDPE manhole shafts where the waste height will be extensive and the stresses on the shaft due to settlement could cause collapse of the shaft.

- *Sidewall pipes*

The use of low angled leachate risers which are laid parallel to the side of the site shall be considered. Although not suitable for sites with steep sides, the system exerts much lower pressures on the liner system. A second advantage is that vertical chambers often suffer from sideways movement due to settlement although the effects of this can be reduced/mitigated by the adoption of telescopic HDPE shafts. The low angle riser system is less prone to damage from the filling process as they are located at the perimeter of the phase.

- *Pumps*

Pumps used to remove leachate from the sumps shall be sized to ensure removal of leachate at the maximum rate of generation. These pumps shall have a sufficient operating head to lift the leachate to the required height from the sump to the access port. One of the most common pump types used is the submersible pumps.

Pumps shall exhibit the following characteristics:

- Easy to install and remove;
- Robust manufacture;
- Minimum moving parts;
- Low maintenance requirements;
- Capable of variable flow rate (varying seasonal conditions). A range from about 60 liters an hour to greater than 1m³/h would be realistic for a pump located within a borehole;
- Capable of running dry with no harm being done to its operation;
- Capable of handling varying quantities of fine material and sludge that often accompanies leachate production, perhaps with additional protection being afforded by filtration; and
- Designed with sufficient head.

3. Leachate Storage

Leachate storage facilities shall consider the following key criteria:

- Concrete tanks designed to BS8007;
- Prefabricated units; and
- Geo-synthetic lined, e.g. HDPE lined facilities.



Such facilities shall be sized to accommodate the calculated leachate volume and shall be designed to prevent overflowing. All units shall be designed to prevent leakages. When using concrete tanks or prefabricated units consideration shall be given to the provision of storage bunds. In situations where it is proposed to line the storage facility with a geo-synthetic material the design/construction and associated quality control/assurance shall follow the general guidance given under *Lining Systems*.

4. Leachate Treatment

Leachate generated from municipal solid waste initially contains high concentrations of organic compounds (of the order of 10,000-40,000 mg/l COD). They also have a low pH, a high ammonia level and an unpleasant odor. To avoid severe environmental impact, the control and disposal of leachate is essential. Discharge limits would normally be specified by the appropriate regulatory agency. Treatment strategies should meet individual discharge conditions and will inevitably be site specific for discharge to municipal sewer, watercourse, land or tidal water.

The Contractor shall ensure that the leachate treatment facility satisfies the following design criteria:

- Be adequate for the varying volumes and composition generated through all stages of development and restoration,
- Be robust, to ensure that performance requirements are maintained throughout and beyond the operational life of the landfill.

A wide range of treatment processes has been adopted for leachate including most of those which have been used for the treatment of domestic and industrial wastewaters.

Table 1 below provides an outline of the most commonly used leachate treatment processes (physical and biological).



Table 1

Leachate Treatment Process	Application
<u>Physical Treatment</u>	
Sedimentation / Flotation	Removal of suspended matter
Filtration	Removal of suspended matter
Air stripping	Removal of ammonia or volatile organics
Steam stripping	Removal of volatile organics
Adsorption	Removal of organics
Ion exchange	Removal of dissolved inorganics
Ultrafiltration	Removal of bacteria and high-molecular-weight organics
Reverse osmosis	Dilute solutions of inorganics
Neutralization	pH control
Precipitation	Removal of metals and some anions
Oxidation	Removal of organics; detoxification of some inorganic species
Evaporation	Where leachate discharge is not permissible
Wet air oxidation	Removal of organics
<u>Biological Treatment</u>	
Activated Sludge	Removal of organics from leachate
Sequencing batch reactors	Removal of organics
Aerated stabilization basins	Removal of organics
Fixed film processes (trickling filters, rotating biological contractors)	Removal of organics
Anaerobic lagoons and contractors	Removal of organics
Nitrification / de-nitrification	Removal of organics

Source: Tchobanoglous 2002

The Contractor shall select the leachate treatment process considered most appropriate to achieve the given objectives.

Treated leachate that is to be disposed of into the receiving environmental shall comply with the Environmental Limit Values (ELVs) stipulated in the Ministry of Environment Decision 8/1 (dated 2001) for either one of the disposal pathways:

- Treated wastewater discharged into the sewerage network (in case treated leachate is transferred to the Al Ghadir Wastewater Treatment Plant).
- Treated wastewater discharged into the sea (in case onsite leachate treatment unit directly discharges treated effluent into the sea)

Table 2 below presents the ELVs set by the MoE Decision 8/1 (2001) for treated wastewater discharged into the sea and sewerage system from new facilities.



Table 2

Parameter	ELV for wastewater discharge into sea	ELV for wastewater discharge into sewerage system
pH	6 – 9	6 – 9
Temperature	35°C	35°C
BOD ₅ (mgO ₂ /L)	25	125
COD (mgO ₂ /L)	125	500
Total Phosphorous (mgP/L)	10	10
Total Nitrogen (mgN/L)	30	60
Suspended Solids (mg/L)	60	600
AOX	5	5
Coliform Bacteria 37°C in 100 ml ³	2,000	Not available
Salmonellae	Absence	Absence
Hydrocarbons (mg/L)	20	20
Oil and Grease (mg/L)	30	50
Total Organic Carbon (TOC) (mg/L)	75	750
Ammonia (NH ₄ ⁺) (mg/L)	10	-
Silver (Ag) (mg/L)	0.1	0.1
Cadmium (Cd) (mg/L)	0.2	0.2
Chromium total (Cr) (mg/L)	2	2
Copper total (Cu) (mg/L)	1.5	1
Mercury total (Hg) (mg/L)	0.05	0.05
Manganese (Mn) (mg/L)	1	1
Nickel total (Ni) (mg/L)	0.5	2
Lead total (Pb) (mg/L)	0.5	1
Zinc total (Zn) (mg/L)	5	10
Nitrate (NO ₃) (mg/L)	90	-
Phosphate (PO ₄) (mg/L)	5	-
Sulfates (SO ₄) (mg/L)	1,000	1,000

Source: MoE Decision 8/14, 2001



Annex 2

Landfill Gas Collection and Flaring Systems



Annex 2 - Landfill Gas Collection and Flaring Systems

Technical and Performance Specifications

1. Landfill Gas Management

The main objectives of landfill gas management are:

- To eliminate the risk of migration of landfill gas within and beyond the perimeter of the landfill site such that there is no risk of explosion, combustion, asphyxiation, odors or vegetation damage on adjoining property,
- To prevent unnecessary air ingress into the landfill and minimize the risk of underground fires,
- To eliminate the need to vent unburned landfill gas to the atmosphere.

Landfill Gas Management is realized by installing Gas Collection and Flaring Systems. The Contractor shall ensure that the landfill gas collection and flaring systems have the following features in order to meet the above objectives:

- A containment system which will retain the gas within the site,
- Gas monitoring boreholes outside the waste boundary where possible,
- Use of safe practices to avoid hazardous concentration of gases in temporary and permanent working areas.

2. Gas Collection Systems

Given that horizontal wells can suffer blockage and dislocation due to differential settlement, gas wells shall be vertical boreholes passing through the waste installed in the waste lifts / layers as landfilling progresses.

The gas extraction system shall consist of vertical extraction wells in the waste, linked by pipework in the cap to a gas pumping and flaring compound. The wells may be constructed as waste filling progresses or drilled retrospectively.

The layout of the wells will be landfill cell specific but normally at not more than 50 m centers together with the positioning of any perimeter migration control system. The wells shall be spaced so that their radii of influence overlap (radius not exceeding 15 m). The spacing can reach 30 m in landfills with clay and/or soil covers and 45 to 60 m in deep landfill cells with a composite cover containing a geomembrane).

The radius of influence for wells shall be determined by conducting on-site gas drawdown tests. The number and spacing between each extraction well will depend on the waste type, compaction and depth, the well depth, the leachate levels, the pressure gradients created by the vacuums, the moisture content of the gas as well as the type of daily cover and the presence of a final cap.

The characteristics of the landfill gas extraction well shall be the following:

- 4 to 6 in. pipe (made of HDPE or PVC) casing surrounded by permeable material (such as gravel) and impermeable seal near the top, placed in an 45 to 90 cm borehole made through waste layers,
- The bottom one third to one half of the well is perforated and placed in a gravel backfill
- The remaining length is not perforated and should preferably be placed in soil, although it can also be set in solid waste backfill,
- A bentonite plug to prevent air infiltration from the surface into the well,
- A wellhead incorporating valves to regulate gas flow and serve as sampling ports, as well as a pressure gauge, a flow monitoring device and a thermometer,
- Pumps/gas blowers to supply the flaring system with landfill gas. The size, type and number of pumps depend on the amount of gas expected to be produced within the landfill,
- Collection header pipes to connect the vertical extraction wells to the gas blowers / pumps,
- Condensate handling equipment placed at low spots in the line where needed and at specific spacing.

The depth of the well shall depend on the depth of the waste and typically terminates at 3 to 5 meters above the base of the waste mass. An area shall also be allocated for standby provision.

The design of the gas management system shall be integrated with other elements of the landfill elements and components considering the following:

- Whether there is sufficient depth in the subsoil component of the capping layers to accommodate well heads and extraction pipes, and
- Whether settlement will disrupt the cap around the well or cause downdrag to push the well against the liner.

3. Pumps and Flares

The flaring system shall be of type enclosed flame flare. The gas extraction pumps and flares shall be designed to meet with emission standards and to comply with national regulations on air quality. Furthermore, Table 1 sets the emission concentrations for landfill gas flares under normal temperature and pressure (NTP: 0°C and 1,013 mbar) and 3% oxygen.

Table 1

Landfill Gas	Emission Standard (mg/Nm³)
Carbon Monoxide (CO)	50
Oxides of Nitrogen (NOx)	150
Unburned Hydrocarbons/ Total volatile organic compounds	10

Source: Emission standards for landfill gas flares (UK Environment Agency, 2010)

The flaring system shall include the following items:

- A purge reduction device to prevent flashback
- A knockout drum to remove and store condensable and entrained liquids
- A flare header to collect the gas
- A liquid seal to prevent flashback
- A flare stack (made of carbon steel with ¼' minimum thickness)
- An externally removable spark ignited pilot
- A steam or air-assist for smokeless flaring
- Auxiliary equipment includes: smoke-suppression control and monitors (for monitoring flow and gas composition)

Table 2 sets basic operational conditions (performance specifications) and physical components that shall be considered for the flaring units.

Table 2

Requirement Type	Requirement	Specification
Operational / Performance	Combustion temperature	minimum of 1000°C
	Residence time	0.3 to 0.5 s
Physical requirement	Automatic pilot restart system	Ensures continuous operation
	Failure alarm with an automatic isolation system	Isolates the flare from the landfill gas supply line, shuts off the blower and notifies the shutdown
	Automatically controlled combustion air louvers	Control the amount of combustion air and the flame temperature
	Source test ports with adequate and safe access	Monitor the combustion process and air emissions sampling
	View ports	Should be available in sufficient numbers to allow visual inspection of the temperature sensor location within the flare
	Heat shield	Placed around the top of the flare shroud and used during source testing

Source: SCS Engineers, 1989; Environment Agency, 2010



Annex 3

Legal Framework



Table of Content

1. Overview on Legal Framework	3
2. Environmental Standards	16
3. MoE Environmental Requirements and Guidelines for the Design and Operation of Sanitary Landfills	16

**MoE Environmental Guidelines and Requirements for the Design and
Operation of Sanitary Landfills**
(Refer to Annex 4)

Environmental Guidelines for Operation of Sanitary Landfills
(Refer to Annex 5)

Legal Framework

This Appendix provides a synthesis of the legal framework related to solid waste management in Lebanon. Relevant policies, regulations, and standards are also outlined.

1.1 Overview on Legal Framework

To date, there is no final legislative framework that directly deals with solid waste management in Lebanon. While the government often relies on indirectly related legislation such as public health acts or anti-litter decrees and the Environment Code Law No. 444 (2002), enforcement of these laws is relatively weak and responsibilities are not well-defined (Table 1 below). Generally, the regulations lack clarity and precision, while coordination between authorities is minimal and enforcement is practically non-existent due mostly to staffing constraints, lack of proper training, low percentages of penalties and fines, and political interferences. Equally important is the lack of awareness of existing regulations amongst personnel who are responsible for enforcing them such as public health inspectors and police officers. In short, the lack of a solid waste legislation constitutes a major obstacle to implement a proper MSW management system in Lebanon.

In year 2005, the Ministry of Environment (MoE) prepared a Draft Law on Integrated Solid Waste Management (ISWM), as part of the Regional Solid Waste Management Project (RSWMP) funded by the EU in the Mashreq and Maghreb countries. The RSWMP was implemented through the Mediterranean Technical Assistance Program (METAP) and managed by the World Bank.

The Draft Law text places a premium on waste “prevention and reduction” in addition to “material reuse, recovery and power generation” and embraces private sector participation in the delivery of SWM services. The main objectives outlined in the Draft Law include:

- Setting the general framework for cost recovery systems,
- Need for preparing and issuing applicable decrees for the Draft Law related to financing and cost recovery systems, and
- Need for strengthening the financial capabilities of the municipalities to accommodate for their responsibilities pertaining to waste collection and treatment, monitoring, and awareness.

The Draft law on ISWM was presented to the Council of Ministers (CoM) in October 2005 and presently awaits the enactment and approval by the Parliament.

Table 1 below outlines and summarizes a list of selected legislations related to the solid waste management sector in Lebanon.

Table 1

Legislation	Date	Official Gazette	Brief description
Decree 2775	1928		<ul style="list-style-type: none"> • Prohibiting the dumping of pollutants into public watercourses.
Decree 7975	5/5/1931		<ul style="list-style-type: none"> • Household sanitization. • Waste should not be dumped around houses, but be buried or removed by the municipality.
Decree 21	22/7/1932	8/8/1932	<ul style="list-style-type: none"> • Classification of establishments that are dangerous or may pose public health problems or cause nuisance. • Definition of associated penalties and fines (penalties and fines updated later).
Decree 2761	19/12/1933		<ul style="list-style-type: none"> • Regulations for disposal of sewage and dirty substances. • Listing of the penalties involved in illegal disposal of municipal and industrial wastes.
Decree 340	01/03/1943		<ul style="list-style-type: none"> • Law on Sanctions and Penalties.
Decree 8377	30/12/1961		<ul style="list-style-type: none"> • Organization of the Ministry of Public Health.
Decision 425/1	8/9/1971		<ul style="list-style-type: none"> • Garbage must be placed in plastic bags for disposal. • Waste must not be dumped on the street or other public places. • Municipalities are responsible for the collection of waste.

Legislation	Date	Official Gazette	Brief description
Decree 8735	23/8/1974	Issue 72 dated 9/9/1974	<ul style="list-style-type: none"> • Preservation of public cleanliness. • Municipalities are responsible for collection and disposal of domestic wastes. • Household and Construction wastes may not be dumped in public places or private land adjacent to roads and residential districts. • It is an offense to drop litter in streets, government buildings, and public areas. • Only tightly closed containers should be used for the storage of refuse. Municipalities may not pile waste on the roadside before it is collected. • Wastes should not be transported in open vehicles, but in vehicles that are tightly covered. • Disposal sites must have the approval of the Health Council of the Mohafaza.
Decree 118	30/06/1977		<ul style="list-style-type: none"> • Law of Municipalities.
Decree 1917	06/04/1979		<ul style="list-style-type: none"> • Specifications on the distribution of assets and the rules of the Independent Municipal Fund finances that has been modified as per Decree No 1783 (10/10/1991).
Decree 11	1978		<ul style="list-style-type: none"> • No insecticide may be imported into Lebanon if it is banned for use in the country of origin.
Law 64	12/8/1988		<ul style="list-style-type: none"> • Preservation of the environment against pollution from hazardous waste and toxic substances • It is the duty of every person to preserve the safety of the environment from pollution. • A list of hazardous waste materials was published (based on English Law). • Import or possession of radioactive or poisonous wastes was prohibited. In extreme cases the death penalty could be applied.
Decision 1292	6/11/1993	Issue 47 dated 25/11/1993	<ul style="list-style-type: none"> • Ministry of Municipal and Rural Affairs (MoMRA) decision related for the organization of construction and demolition waste within the city of Beirut.



Legislation	Date	Official Gazette	Brief description
Law 197	18/2/1993	Annex to Issue 7 18/2/1993	<ul style="list-style-type: none">• Creation of the Ministry of Municipal and Rural Affairs (MoMRA).• The MoE is responsible of the development of the municipal sector in areas such as strategic planning, budgeting, and programming, as well as auditing the functions of the various municipalities in Lebanon.• Law 247 of 9/8/2000 (Issue 35 dated 14/8/93) cancels the MoMRA and merges its departments into the Ministry of Interior, thus creating the Ministry of Interior and Municipalities (MoIM).
Law 387	4/11/1994	Issue 45 dated 10/11/1994	<ul style="list-style-type: none">• Ratification of Basel Convention for the Transport of Hazardous Waste by Lebanon.
Law 359	1/7/1994	Issue 32 dated 11/8/1994	<ul style="list-style-type: none">• Ratification of the Climate Change Convention by Lebanon (this means that greenhouse gas emissions should be reduced; i.e. methane and carbon dioxide in the case of solid waste landfills).
Decree 4917	24/3/1994	Annex to Issue 13 31/3/1994	<ul style="list-style-type: none">• Amendment of Table 1 (Item 204) in Decree 21 dated 22/7/1932, Classification of establishments that are dangerous or may be public health issue or cause nuisance.
Law 501	6/6/1996	Issue 24 dated 17/6/1996	<ul style="list-style-type: none">• Establishes an agreement to accept a loan from the World Bank to implement a Solid Waste Environmental Management Project (SWEMP) in Lebanon.• Components of the project include establishing sanitary landfills nationwide and institutional capacity building for the government relating to solid waste management.
Decision 52/1	29/6/1996	Issue 45 dated 12/9/21996	<ul style="list-style-type: none">• Revised standards for water, air and soil pollution (partly updated in Decision 8/1 dated 30/1/2001).
Law 667	29/12/1997	Issue 59 dated 30/12/1996	<ul style="list-style-type: none">• Creation of Ministry of Environment (MoE).• Amendment of Law 216 (dated 8/4/1993).
Decision 71/1	19/5/1997	Issue 28 dated 7/6/1997	<ul style="list-style-type: none">• Amendment of Decision 22 /1 of 17/12/1996.• Regulates the import of waste and defines associated penalties.



Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 58	2/1/1997	In effect since 1997	<ul style="list-style-type: none">Provides a framework for SWM in Beirut and most of Mount Lebanon (Kesrouan, Metn, Baabda, Aley, and Chouf) excluding the Caza of Jbeil.
Law 247	9/8/2000	Issue 35 dated 14/8/2000	<ul style="list-style-type: none">Annuls the MoMRA and merges its departments into the Ministry of Interior thus, creating the Ministry of Interior and Municipalities (MoIM).
MoE Decision 4/1	12/01/2001	NA	<ul style="list-style-type: none">Setting environmental guidelines to authorize the establishment and/or operation of slaughterhouses.
MoE Decision 8/1	30/1/2001		<ul style="list-style-type: none">Amendment to part of MoE Decision 52/1 dated 29/6/1996.Revised standards for air stack emissions, liquid effluents, and wastewater treatment plants (National Standards for Environmental Quality - NSEQ).
Decree 8006	21/6/2002	Issue 36 dated 21/6/2002	<ul style="list-style-type: none">Definition of waste categories generated by medical establishments and treatment and disposal options.
Decree 9093	15/11/2002	Issue 63 dated 21/11/2002	<ul style="list-style-type: none">Amendment of Decree 1917 dated 6/4/1979.States that any municipality that constructs a sanitary landfill or a waste treatment facility on its lands will get 5 times its allotted share of municipal funds from the Independent Municipal Fund, and if this municipality accepts wastes from 10 other municipalities its share will be 10 fold its allotted share.



Legislation	Date	Official Gazette	Brief description
Law 444	29/7/2002	Issue 44 dated 8/9/2002	Environment Protection Law (7 parts, 68 articles) outlining the: <ul style="list-style-type: none">• Fundamental principles and public rules,• Organization of environmental protection,• Environmental information system and participation in the management and protection of the environment,• Environmental Impact Assessment,• Protection of environmental media,• Responsibilities and fines, and• Other regulations (miscellaneous, institutional).
Draft Decree	2003		<ul style="list-style-type: none">• Management of industrial and hazardous waste Decree.• The Decree pertains to the classification of industrial and hazardous waste.• MoE is responsible for enforcement and monitoring.• Identification, handling, storage, transport, treatment, disposal, record keeping procedures are addressed.• MoE is responsible for plans and strategies, enforcement and monitoring.• Producer is responsible for waste treatment/disposal.• Sanctions placed in cases of violations.
Draft Decree	2003		<ul style="list-style-type: none">• Permitting institutions managing industrial and hazardous waste.• MoE grants permits.• Procedures for requesting permits for transport, storage, treatment and disposal of industrial and hazardous waste are addressed.• MoE is responsible for enforcement and monitoring.• Sanctions placed in cases of violation.• Provides guidelines for disposal operations.• Provides guidelines for industrial and hazardous waste landfill sites.



Legislation	Date	Official Gazette	Brief description
Decree 13389	18/09/2004		<ul style="list-style-type: none">• Amends Decree No 8006 (dated 11/06/2002).• Identifies the types of healthcare waste and disposal methods.
Draft Law	2005		<ul style="list-style-type: none">• Reducing the quantity of waste for landfilling to the highest extent possible.• Assisting in the management of solid waste and the promotion of recycling and composting.• Specifying the institutional framework for solid waste management.
Law 690	2005	26/08/2005	<ul style="list-style-type: none">• Sets the jurisdiction, role, and organization of the MoE.
Decree 2275	2009	15/06/2009	<ul style="list-style-type: none">• Organization of the services and departments of the MoE.• Specifies the role of each service / department and the enrollment conditions.
CoM Decree 2366	20/06/2009		<ul style="list-style-type: none">• Council of Ministers approved the National Physical Master Plan for the Lebanese Territory (NPMPLT) for Lebanon which describes the physical realities affecting land use, future challenges, alternative configurations for land use and development, land use principles and sectorial action plans (Chapter 6, State and Trends of the Lebanese Environment).• The NPMPLT proposes a unified set of land use categories covering the entire territory, and delineated several protection zones of ecological significance. The categories are as follows: U: Urban, R: Rural, A: Agricultural, N1: Natural/Peaks, N2: Natural/Cedars, N3: Natural/Corridor P: View area of natural sites, S1: 500 radius around classified sites, S2: 500 radius around special natural sites, F: Prone to flooding, G: Prone to landslides and rock fall-down, W: Prone to underground water pollution.

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 55	01/09/2010	NA	<ul style="list-style-type: none"> • Consider the National Municipal Solid Waste Management Plan for Lebanon in 2006. • Establish Waste-to-Energy plants in large cities. • Enact legislations through the Ministry of Energy and Water to allow the production and selling of power produced at the Waste-to-Energy plants. • Include private sector participation (PSP) in the solid waste management across Lebanon through a Turn-key contract (collection and treatment including landfilling) or 2 different operations (collection and treatment). • Implementation of incentives to municipalities where solid waste treatment facilities are to be located.
Ministry of Environment Decree No 8633	2012	16/08/2012	<ul style="list-style-type: none"> • Sets the procedures and principles for the preparation of an Environmental Impact Assessment (EIA) study. • Categorizes establishments and projects according to the needed environmental assessment studies (Environmental Impact Assessment, Initial Environmental Examinations, etc.).

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 46	30/10/2014	NA	<ul style="list-style-type: none"> • CDR to prepare TOR for an open tender to contract sweeping and collecting solid waste within Beirut, most of Mount Lebanon and North Lebanon governorates. • CDR to prepare TOR for a tender to contract solid waste management services that include separation, composting, energy recovery, and landfilling of non-organic waste in Beirut, most of Mount Lebanon and North Lebanon governorates. • Service Lots divided as follows: <ul style="list-style-type: none"> <u>Beirut Mohafaza and Most of Mount Lebanon Mohafaza</u> <ul style="list-style-type: none"> - Chouf Caza, Aaley Caza, and Part of Baabda Caza - Most of Southern Suburbs of Beirut - Beirut City and Part of Baabda Caza - Metn Caza and Kesrouan Caza <u>North Lebanon Mohafaza</u> <ul style="list-style-type: none"> - North Lebanon Mohafaza • Decisions defining the roadmap for an Integrated Solid Waste Management Plan including: <ul style="list-style-type: none"> - OMSAR in coordination with MoE to continue with the management of MSW sorting and co posting facilities that have been already established and to establish new integrated solid waste management facilities through donations funded by the European Union to OMSAR. - Assign the CDR to request from the international consultant RAMBOLL to proceed with Phase 2 of its contract, which involves the preparation of the tender documents for a MSW incinerator, that are to be adopted by the cabinet. - Assign MoE to several tasks including: initiate awareness source separation and decentralized solid waste management; Prepare a Strategic Environmental Assessment for a draft long-term solid waste management strategy; Prepare a health risk assessment of the Naameh Landfill and the Tripoli Controlled Dumpsite; Prepare a long-term program for environmental monitoring after the closure of Naameh Landfill and the Tripoli Controlled Dumpsite. <p><u><i>This CoM Decision (46, 2014) has been amended by the CoM Decision 1, 2015.</i></u></p>



Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	12/01/2015	NA	<ul style="list-style-type: none">• Amendment of CoM Decision 46 (30/10/2014).• Some of the main articles/issues addressed in the Decision:<ul style="list-style-type: none">- 60% waste recovery from the sorting, recycling, composting and energy recovery during the first three (3) years of contract, and 75% in the following years up to thermal treatment (including Refuse-derived Fuel RDF or incineration or others).- Disposal of MSW refuse through the rehabilitation of degraded sites (quarries) and/or other uncontrolled dumpsites or other sites that might require rehabilitation to be defined by the CoM based on the MoE recommendations, on the basis of having at least one (1) sanitary landfill within each Service Area/Lot (proposed landfill site/s for Service Lot 1 shall be located outside the boundaries of this Lot).- Assign the CDR to request from the international consultant RAMBOLL to proceed with Phase 2 of its contract, which involves the preparation of the tender documents for a MSW incinerator, to be completed within 6 months at most and subsequently, to be discussed by the cabinet.- Request the CDR to temporarily resume operations as per the current MSW Plan no longer than 3 months that may be extended for one last time, 3 additional months.• Service Lots divided as follows:<ul style="list-style-type: none">- Beirut City and Northern and Southern Suburbs- Metn Caza, Kesrouan Caza, and Jbeil Caza- Chouf Caza, Aaley Caza, and Part of Baabda Caza- North Lebanon Mohafaza and Aakkar Mohafaza- South Lebanon Mohafaza and Nabatieh Mohafaza- Bekaa Mohafaza and Baalbeck – Hermel Mohafaza

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	09/09/2015	NA	<p>Some of the Decision's main clauses include:</p> <ul style="list-style-type: none"> • Adopt the principle of treatment decentralization and offer the municipalities and union of municipalities a role in upholding the responsibility of the MSW management, as part of the MSW Treatment Plan. • Adopt two sanitary landfills to be set up and made operational in accordance with environmental standards in the area of Srar in Akkar and Masnaa area in the Anti-Lebanon Mountains, and the use of Saida waste treatment plant to receive part of the solid waste during the interim period. • CDR to prepare the necessary studies with the Ministry of Environment to rehabilitate the Ras El Ain dumpsite. • Notify the current operator for the Beirut and Mount Lebanon service area of the non-renewal of the treatment and landfilling contracts, and the non-renewal of the supervision contract on the treatment and landfilling works. • CDR to extend the sweeping, collection and transportation contract with the current operator for a period that does not exceed 18 months from the date the Council of Ministers accedes the extension.

Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	21/12/2015	NA	<p>Some of the Decision's main clauses include:</p> <ul style="list-style-type: none"> • For a transitional phase, CDR charged to handle the waste export process according to relevant local laws and international treaties. • Provisional approval for signing a service agreement with Chinook Urban Mining International and HOWA BV to export the wastes. • Contracting with a consulting firm to supervise the export works after approval of the Council of Ministers. • Negotiating with Chinook Urban Mining International to operate the sorting and treatment facilities within Beirut area and part of Mount Lebanon during the contract period (18 months). • Current operator and supervisor to continue carrying on sorting and treatment operations until reaching an agreement with Chinook Urban Mining International for the operation of existing treatment facilities. • Confirmation of Decision 46 (30/10/2014) to prepare a tender document for sweeping and collection after the expiry of contracts with Chinook Urban Mining International and HOWA BV. • Confirmation of Decision 55 (01/09/2010) to adopt Waste-to-Energy and commission CDR to prepare the necessary tender document to be completed within 2 months from the date of CoM Decision.



Legislation	Date	Official Gazette	Brief description
Council of Ministers (CoM) Decision 1	17/03/2016	NA	<p>Some of the Decision's main clauses include:</p> <ul style="list-style-type: none">• Amendment of CoM Decision 1 (12/03/2016).• The establishment of a temporary sanitary landfill in Bourj Hammoud, Jdeideh - Al Bouchriyah - Al Sadd, a temporary sanitary landfill and a treatment facility in the proximity of Al Ghadir river outlet, the removal of Bourj Hammoud dumpsite and the demolition wastes near Al Ghadir river outlet. The daily quantity of waste to landfill in Bourj Hammoud and Jdeideh - Al Bouchriyah - Al Sadd center should not exceed 1,200 tons.• Treatment and disposal centers in Bourj Hammoud and Jdeideh - Al Bouchriyah - Al Sadd should not be established after 4 years.• Re-opening of Nehmeh landfill for only 2 months before its final closure equally dispense the deducted percentage from the Independent Municipal Fund to the municipalities of Nehmeh, Aabey, Ain Drafil, Baawerta and Aramoun.• Establishment and improvement of treatment and sorting centers and sanitary landfills in compliance with scientific and environmental requirements and regulations and in collaboration with concerned municipalities, especially with regard to the control and monitoring of filters, solid waste rejects and continuous electricity provision.• Other clauses related to the securing of funds and other administrative issues.



2. Environmental Standards

The Ministry of Environment (MoE) has introduced national quality standards for air, water, soil, and noise in the context of Decision No. 52/1 dated July 1996. In addition, Decision No. 8/1 dated March 2001 included emission standards for air emissions and wastewater quality and discharge, presented in the National Standards for Environmental Quality (NSEQ) reference book.

3. MoE Environmental Requirements and Guidelines for the Design and Operation of Sanitary Landfills

The Ministry of Environment has prepared and outlined design requirements and environmental guidelines for the operation for sanitary landfills. MoE Environmental Guidelines are presented hereinafter.

Annex 4
Design Requirements for Sanitary Landfills

Design Requirements for Sanitary Landfills

The Ministry of Environment approves, from the environmental point of view, the design of landfills (defined in article 1) after giving its approval on the relevant environmental impact assessment studies, provided it makes sure that all the corrective measures suggested in the environmental impact assessment studies as well as the design requirements for sanitary landfills (defined in article 2) have been taken into consideration.

Article one

Definition of sanitary land filling and sanitary landfills

1-1 Land filling

It is the eco-friendly means of getting rid of solid domestic waste which cannot be managed in another way and which resulted from the refuses of recycling, composting, burning, and other operations related to solid domestic waste.

Land filling is one of the essential elements in any strategy and plan aiming at achieving an integrated solid domestic waste environmental management.

1-2 Landfills

They are the lands or special land, set areas used to dispose of waste resulted from the refuses of recycling, composting, burning, and other operations related to solid household waste. After designing it and equipping with the suitable technical and engineering devices, these landfills can receive the waste, shrink its volume and cover it with a sand layer regularly without causing any negative impacts on the environment, health, and public safety.

Article two

Landfills design requirements

According to the Ministry of Environment's solid domestic waste management strategy, the design of a sanitary landfill requires that:

- 2-1 The landfill capacity be large enough to receive the volume of the waste resulting from the area population served by the landfill, for thirty years, taking into consideration the following points:

- 2-1-1 Demographic growth during that period which increases solid domestic waste quantity, in addition to the changes in commercial, industrial, and touristic activity in the area.
- 2-1-2 Quality of the waste to be land filled resulted from the different stages and elements of the solid domestic waste management plan in the area. (Sorting, composting...)
- 2-1-3 Quantity of daily-required soil for covering, as well as the final top isolating layer.
- 2-1-4 Reduction of the different layers of the landfill due to the decomposition and the compression of the landfilled waste caused by the weight of layers above it.
- 2-2 The landfill be designed in a way to ensure the isolation of its floor so the lecheate resulting from the decomposition of the waste can be gathered and prevented from leaking to underground and surface water. The landfill floor-isolating liner should be composed of a clay liner, covered by HDPE membrane liners, a cushion liner, and a high permeability layer.
 - 2-2-1 Clay liner: many tests must be carried out to determine the permeability of the isolating clay liner, the best moisture level, the required pressure to compress this layer, and its pitch level, before adopting it in order to ensure a permeability speed less than 10^{-7} /sec. This liner should be placed on compacted bedrock of more of 3-meter thickness.
 - 2-2-2 Membrane liners: they must be compatible with the nature of landfilled waste to prevent lecheate leaking through it. Its effectiveness must not be affected by the chemical characteristics of that lecheate and of the waste quality.
 - 2-2-3 Cushion liner to protect the above mentioned membrane liner.
 - 2-2-4 High permeability layer usually composed of basalt.
- 2-3. The landfill design shall be based on cell system. That way, the work will be done gradually and/or according to the type of the landfilled waste. This is aimed to organize work in the landfill according to the suggested design, to facilitate monitoring of land filling and to calculate the

remaining life of the landfill to compare it to the original timetables accordingly any deviation will be subject to corrective measures.

2-4 Design a complete management system for the lecheate resulting from waste decomposition and polluted rainwater, entitling collection till treatment, it should include the following equipments:

2-4-1 Perforated pipes (with 1% incline) placed on the membrane layers with the suitable incline (2-4%) at their lowest level to ensure the lecheate flowing in the pipes and reaching the collection tanks.

2-4-2 A treatment station designed to treat the lecheate and ensure that the characteristics of water –once treated- comply with the national environment standards.

2-4-3 Underground wells fitted in the landfill area to determine underground water quality prior to operating the landfill, to monitor any landfill leakage towards them, and to ensure that underground water characteristics remain in agreement with the ones set before landfill exploitation. The number, position, and depth of the wells are to be determined according to the landfill's location and geological and hydro geological nature.

2-5 Design a management system of the gases resulting from the decomposition of the organic material present in the waste, entailing the collection recapturement and/or burning of gases avoid any explosions due to the increase of methane concentration beyond the allowed limit, in addition to avoid any damage that this gas causes to the environment The gas management system shall depends on the following type of equipments and methods:

2-5-1 Suitable engineering methods (isolating layers) inside the landfill in a way to prevent gas dispersion into the lands surrounding the landfill.

2-5-2 Perforated pipes that allow the capturing of the gas and conveying it to the landfill rooftop through an exhaust.

2-5-3 A gas burner or a gas collection and purification system

2-5-4 Probes set within the landfill surroundings to monitor gas outflow from the landfill to the surrounding lands.

- 2-6 The final use of the landfill following its closure it be set in addition to the design of its upper layer. This should be done through studying of the landfill location and its original surroundings nature enabling to define the kind of plants that can be planted in it and the kinds of animals which can survive in that area. After that, a final use proposal should be set provided it will be composed of the following items: isolating layer, agricultural soil layer, rainwater and running water draining system.
- 2-6-1 The isolating layer aims at stopping or reducing rainwater leaking to filled waste. It is composed of two parts:
- Part one: membrane liners placed on the sand layer that covers the last layer of landfilled waste
 - Part two: clay liner, 60 to 100 cm thick, placed above the above mentioned membrane liner.
- 2-6-2 The agricultural soil layer, which is the soil layer, placed on the top of the landfill to make it cultivable. It is composed of two parts:
- A 30-cm thick sand layer placed directly over the above-mentioned clay liner (an additional membrane layer can be placed to separate this layer from the clay liner)
 - Agricultural soil layer, no less than 70-cm thick, whose characteristics are in agreement with the characteristics of the agricultural soil surrounding the landfill.
- 2-6-3 Rainwater drainage system: it relies on providing suitable inclines in the landfill's final upper layer. The inclines allow rainwater to flow into aqueducts built in the lower levels of the inclined layers and to lead it to nearby winter water aqueducts or to special tanks in order to be collected when necessary.
- 2-7 The required infrastructure for the landfill's functioning be designed., such as:
- 2-7-1 Inner roads: their width, incline... in a way suiting the used trucks and the expected work rate.
- 2-7-2 Rainwater and water draining networks.

2-7-3 Lecheate treatment plant

2-7-4 Balance for trucks: suiting the type of trucks used or might be used.

2-7-5 Building(s) of the management, guards, restrooms, and other...

8-2 The surrounding of the real estate shall be tree-planted as well as the roads leading to and from the landfill.

Article three

The Ministry of Environment studies the complete submitted during a 15-working day period and informs the side responsible for the file about its notes in order that they can be modified it as required before construction of the landfill takes place.

Article Four:

The party responsible for the establishment of the landfill pledges not to adopt any major change in the design approved by the Ministry of Environment, before getting new approval.

Article Five:

The Ministry of Environment reserves its right to perform regular monitoring throughout the establishment of the landfill and to ask for the modifications that it deems necessary to safeguard the environment and preserve natural resources.

Annex 5
Environmental Guidelines for Operation of Sanitary Landfills

Environmental Guidelines for the Operation of Sanitary Landfills

The Ministry of Environment approves, from the environmental point of view, the establishment and operation of sanitary landfills (defined in article 1) in view of safeguarding the environment, preserving natural resources and limiting the impact of pollutants generated by those landfills (defined in article 2), through the implementation of certain environmental guidelines (detailed in article 3).

Article one

Definition of land filling and landfills

1-1 Land filling

It is the eco-friendly means of getting rid of solid domestic waste which cannot be managed in another way and which resulted from the refuses of recycling, composting, burning, and other operations related to solid domestic waste.

Land filling is one of the essential elements in any strategy and plan aiming at achieving an integrated solid domestic waste environmental management.

1-2 Landfills

They are the lands or special land, set areas used to dispose of waste resulted from the refuses of recycling, composting, burning, and other operations related to solid household waste. After designing and equipping it with the suitable technical and engineering devices, these landfills can receive the waste, shrink its volume and cover it with a sand layer regularly without causing any negative impacts on the environment, health, and public safety.

Article two

Definition of general pollutants resulting from the operation of sanitary landfills

The operation of sanitary landfills produces the following waste:

- 2-1 Liquid waste. It is the leachate resulting from the degradation of landfilled solid domestic waste itself, in addition to polluted rainwater due to its mixing with landfilled solid waste. The liquid waste contains dissolved organic materials, suspended solid materials, and characterized

by high biological and chemical demand for oxygen, and a variation in the Ph.

It comes also from oil and greases resulting from machines, equipments, and power generators maintenance.

- 2-2 Solid waste, basically waste which is not allowed to be landfilled (i.e. hazardous waste)
- 2-3 Air pollution: a mix of gases resulting from the decomposition of the organic material in waste in anaerobic conditions. This mixture mainly contains methane and carbon dioxide.
In addition, dust is produced from the daily covers used in the landfill as well as combustion gases from machines, equipments, and power generators used.
- 2-4 Noise pollution. It results from the machines and equipments used in the landfill and liquid waste treatment plant, and from power generators and truck movement from and to landfill site.

Article three

Required general environmental guidelines in operating sanitary landfills

3-1 Water management

- 3-1-1 Rationalizing water usage to maintain the sustainability of water resources.

3-2 Liquid waste management

- 3-2-1 Ensure no liquid waste leakage into nature and surface and underground waterways.
- 3-2-2 Providing a closed and independent tank to drain liquid waste resulting from the landfill and handle it in a way that guarantees that its characteristics- once treated- comply with the national environmental standards.
- 3-2-3 Draining treated water into the sea or surface water, the flow of which is no less than 0.1 m³/sec according the national environmental standards. When impossible, supply the Ministry of the Environment with a document that sets the water-disposal method in order to discuss it and get approval for it before applying it.

3-2-4 Construct underground wells in the landfill area to determine underground water quality prior to operating the landfill, to monitor any landfill leakage towards them, and to ensure that underground water characteristics remain in agreement with the ones set before landfill exploitation.

3-2-5 Running regular tests on samples taken from treated liquid waste and from surface and underground water, as follows:

- After treating liquid waste: **test frequency:** every three months.

Indications that should be monitored: the biological and chemical demand for oxygen, PH, dissolved material, suspended solid material.

- Surface and underground water: **test frequency:** every 6 months.

Indications that should be monitored: the biological and chemical demand for oxygen, PH, suspended solid material.

3-2-6 Keeping clear records showing test results of the different samples of liquid waste before and after treatment, and of underground and surface water.

3-2-7 Providing the Ministry of Environment with regular tests of different sample results to monitor the extent of the compliance of its characteristics with national environmental standards.

3-2-8 Taking all suitable corrective measures when any error in the tests mentioned in paragraph 3-2-5 appears after taking the approval of the Ministry of Environment.

3-2-9 Collecting greases and oil resulting from the maintenance of used power generators, machines and equipments in closed special containers in preparation for its delivery to the recycling sites.

3-3 Solid waste management

3-3-1 Receiving solid domestic waste in well-packed bails and in closed containers to prevent waste falling and dispersing.

- 3-3-2 Monitoring a representative number of packed solid waste before land filling it in order to check that it does not contain unauthorized waste to be land filled (i.e. hazardous waste)
- 3-3-3 Notifying the Ministry of Environment of any waste unauthorized to be land filled, especially hazardous waste, so that its quality, the responsible sender, and the eco-friendly way to dispose of it can be determined.

3-4 Air pollution management

- 3-4-1 Fitting a management system of the gases resulting from the decomposition of the organic material present in the waste, in order to collect them, recapture them, or burn them using the proper technical methods which guarantee the compliance of its characteristics with national environmental standards.
- 3-4-2 Fitting the landfill with suitable engineering methods (isolating layers) in a way to prevent gas leakages in addition to ensure that solid domestic waste are covered with a sand layer of an adequate thickness to prevent the dispersion of gases that cause foul odors.
- 3-4-3 Fitting the landfill with probes to monitor gas leakage from the landfill into nearby lands.
- 3-4-4 Monitoring methane concentration level in the air to ensure of the efficiency of the gas management system mentioned in paragraph 3-2-1.
- 3-4-5 Tree-planting the landfill area with tall forest trees that go with the nature of the area to isolate odors and dusts from the landfill's outer surroundings.
- 3-4-6 Asphalting the roads leading to the landfill and showering them regularly with water to prevent the spreading of dusts due to the running trucks and vehicles.
- 3-4-7 Placing power generators in closed special rooms and fitting their exhausts with filters that guarantee the compliance of their emission characteristics with national environment standards.

3-4-8 Maintaining trucks and vehicles engines regularly to ensure efficient combustion of fuel.

3-4-9 Compliance of air pollutant characteristics with national environment standards.

3-5 Noise pollution management

3-5-1 Fitting machines that are considered noise polluting with mufflers and placing them in soundproof rooms as well as maintaining them constantly.

3-5-2 Fitting the power generator with a muffler that guarantees the compliance of the resulting noise level characteristics with national environmental standards.

3-6 Other general conditions:

3-6-1 Ensure the appropriate quantities of soil used in the daily coverage process, in a way to guarantee the isolation of the waste layer and its compliance with the design requirements;

3-6-2 Provide workers and technicians with the proper personal protection equipment (masks, special clothes, proper shoes);

3-6-3 Prohibit smoking and put warning signs against it;

3-6-4 Applying sound environmental practices continuously;

Article Four:

The Ministry of Environment specifies the final required environmental guidelines for the operation of landfills based on the location of each site, the adopted processing stages and the produced pollutants (through modification of certain conditions stated in article 3).

Article Five:

The Ministry of Environment reserves its right to impose additional environmental guidelines when needed and to perform regular monitoring to verify the continuous implementation of the required environmental guidelines.