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# **Rehabilitation of Mufti Hassan Khaled Garden Beirut - Lebanon**

## **TENDER DOCUMENTS**

### **Technical Specifications**

Part 1 of 4  
Civil Works

**August 2024**

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## SECTION 01100

### SUMMARY

#### PART 1 GENERAL

##### 1.1 SECTION INCLUDES

- A. Contract description.
- B. Contractor's use of site.
- C. Coordination.
- D. Work sequence.
- E. Employer occupancy.
- F. Specification conventions.

##### 1.2 CONTRACT DESCRIPTION

- A. Scope:
  - 1. This Specification covers the construction and completion of the project as shown on the Drawings, **Bill of Quantities**, and as detailed in the Contract Documents and directed by the Engineer.
  - 2. The Contract comprises execution, completion of the works and remedying any defects therein including the provision of all labor, materials, constructional plant, temporary works and everything whether of a temporary or of a permanent nature required for the proper execution and completion of the works.
  - 3. Perform Work in accordance with the Contract Documents.
  - 4. The requirements of these Specification Sections do not supersede or take precedence over any provision of the relevant local authorities' regulations, requirements and conditions, and should any discrepancy become apparent between the said documents, the Contractor shall notify the Engineer, in writing, with a copy to the Employer, and the Engineer shall interpret and decide such matters in accordance with the applicable provisions of the Tender Documents.
  - 5. The organization of the Specifications into Divisions, Sections and paragraphs and the arrangement of Drawings shall not necessarily control the Contractor in dividing the Work among sub-contractors or in establishing the extent of Work to be performed by any trade.
  - 6. In examining the requirements of any section of the Specifications, the Contractor shall examine all other sections of the Specifications and the other Documents and Drawings which affect the Work of that section.
  - 7. It is the responsibility of the Contractor, to inform the Engineer of any discrepancies in the drawings and specifications before signing the Contract, default of which will make him responsible for any errors or omissions even though they have been approved by the Engineer.

- B. Description of the Project:
1. The project location is as shown on the drawings.
  2. The project comprises the construction, completion and maintenance during the defects liability period of the Works related to the project with all related siteworks, civil and architectural works, and electromechanical works, all as defined in the Tender Documents.
- C. Performance and Standards:
1. The performance required of materials and products and the standards to be complied with shall be as specified in subsequent sections of these Specifications and in accordance with local relevant authorities' standards (LIBNOR, etc.) which ever have more stringent requirements.
- D. Cross References:
1. The specifications are prepared based on the Construction Specifications Institute (CSI) master format.
  2. The specifications section numbers and titles are used in the **Bill of Quantities** as cross-references to help define the part or parts of the Specification which apply to particular kinds of work or parts of the Work. If the references are to specific clauses or kinds or types of work within a section of the Specifications, they shall be taken as applying to the section as a whole, with all related sections and other relevant information. Cross references should not be taken as excluding other relevant information and requirements stated in other parts or sections of the Specifications. The Specifications as a whole shall be taken as applying to the Work as a whole.

### 1.3 CONTRACTOR'S USE OF SITE

- A. All construction operations and site establishment facilities shall be confined to within the site boundaries unless otherwise agreed with the Engineer and the Employer.
- B. The Contractor shall be responsible for safeguarding existing structures and utilities.
- C. The Contractor shall be responsible for arranging his own working space, storage of materials, setting of all temporary accommodations, utilities, services, facilities, etc. subject to the approval of the Engineer.
- D. The Contractor shall be responsible for keeping driveways and entrances serving the site clear and available to the Employer, other Contractors, the Employer's employees and emergency vehicles at all times. Do not use these areas for parking or storage of materials. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.
- E. The Contractor shall be responsible for not unreasonably encumber the site with materials or equipment. Confine stockpiling of materials and location of storage sheds to the areas proposed by the Contractor at Tender stage, after having received the approval of the Engineer. If additional storage is necessary, obtain and pay for such storage off site.

- F. The Contractor shall be responsible for locking automotive type vehicles, such as passenger cars and trucks, and other mechanized or motorized construction equipment, when parked and unattended, so as to prevent unauthorized use. Do not leave such vehicles or equipment unattended with the motor running or the ignition key in place.
- G. The Contractor shall be responsible for implementing safety measures and procedures at all times.

#### 1.4 COORDINATION

- A. The Contractor shall be responsible to coordinate the works of all trades (Civil, Architectural and Electro-Mechanical Works) related to the project.
- B. The Contractor shall ensure that the Works are carried out in a proper sequence having regard to the works progress, and that all necessary provisions are made for locating, routing, supporting and fixing the engineering services, providing necessary holes, chases and access for them, and in all respects fully integrating them with the works.
- C. The Contractor shall fully coordinate and cooperate with other Contractors on site.

#### 1.5 WORK SEQUENCE

- A. Construct Work in approved stages and phases.
- B. Coordinate construction schedule and operations with Engineer.

#### 1.6 EMPLOYER OCCUPANCY

- A. The Employer will be occupying the site and premises during the works together with other contractors executing other works on site.
- B. Cooperate with Employer to minimize conflict and facilitate Employer's operations.
- C. Schedule the Work with the Engineer to accommodate Employer occupancy.

#### 1.7 SPECIFICATION CONVENTIONS

- A. These specifications are written in imperative mood and streamlined form. This imperative language is directed to the Contractor, unless specifically noted otherwise. The words "shall be" are included by inference where a colon ":" or semi-colon ";" is used within sentences or phrases.
- B. Related Sections: All "Division 1" specifications sections are general requirement sections and are applicable to all other specifications sections and no need to mention them in the "Related Sections" of each specifications section; In general, "Related Sections" are only the "Technical Related Sections".

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

Not Applicable.

END OF SECTION

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## SECTION 01300

### ADMINISTRATIVE REQUIREMENTS

#### PART 1 GENERAL

##### 1.1 SECTION INCLUDES

- A. Coordination and project conditions.
- B. Field engineering.
- C. Regulatory Requirements.
- D. Management and Administration Procedures.
- E. Progress meetings.
- F. Pre-installation meetings.

##### 1.2 COORDINATION AND PROJECT CONDITIONS

- A. Coordinate scheduling, submittals and Work of various sections of the Project to ensure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
- B. Verify utility requirements and characteristics of operating equipment are compatible with project utilities. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, operating equipment.
- C. Coordinate space requirements, supports and execution of all trades and works. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance and for repairs.
- D. Coordinate completion and clean-up of Work of separate sections in preparation for Substantial Completion.

##### 1.3 FIELD ENGINEERING

- A. Scope:
  - 1. This section covers:
    - a. Survey and field engineering, quality control, submittals and project record documents of the works.
    - b. The Contractor's responsibility for the accurate setting out of the Works both on drawings and on Site.
- B. Related Items:
  - 1. General Requirements: Execution requirements for project record documents.

- C. Performance and Standards:
1. Employ a Certified Land Surveyor acceptable to the Engineer to perform survey work of this section.
  2. All setting out, including the setting out and marking of builder's work requirements shall be measured from agreed data.
- D. Submittals:
1. Submit name, address, and telephone number of Surveyor before starting survey work.
  2. On request, submit documentation verifying accuracy of survey work.
  3. Submit a copy of site drawing signed by the Certified Land Surveyor, that the elevations and locations of the Work are in conformance with Contract Documents.
  4. Maintain a complete and accurate log of control and survey work as it progresses.
- E. Survey Equipment: Provide the following minimum survey equipment for each trade of work.
1. [1 No] Automatic Leveling Instruments with Graduated Magnified 3600 Horizontal Circle and Telescope Magnification of 20 x (minimum).
  2. [1 No] Theodolites (to 20 seconds intervals).
  3. [2 No] 4m Staff.
  4. [8 No] Ranging Rods.
  5. [1 No] Linen / Glass Fiber Tape (30m).
  6. [1 No] Linen / Glass Fiber/Steel Tape (50m).
  7. [1 No] Steel Tapes (coated) (3m).
  8. [1 No] Steel Tapes (coated) (5m).
  9. [1 No] Builders Spirit Level (1m long).
  10. [1 No] Magnetic Pipeline Coating Thickness Tester (0-1000 micron).
  11. [1 No] Caliper for Measuring Pipes of Up to 900mm Diameter.
  12. [1 No] 1 lb. Claw Hammer.
  13. [1 No] 4 lbs. Square Face Hammer.
  14. Level Hooks [As Required].
  15. [1 No] Chlorine Comparator with Tablets for Testing of Chlorine in Water Samples from 0.1 to 1.0 ppm.
  16. Others [As Required].
- F. Examination:
1. Verify locations of survey control points prior to starting work.
  2. Promptly notify Engineer of any discrepancies discovered.
- G. Survey Reference Points:
1. Contractor will locate and protect survey control and reference points.
  2. Control datum for survey is that indicated on Drawings or as given by the Engineer.
  3. Verify set-backs and easements; confirm drawing dimensions and elevations.
  4. Protect survey control points prior to starting site work; preserve permanent reference points during construction.
  5. Replace dislocated survey control points based on original survey control. Make no changes without prior written notice to Engineer.

- H. Survey Requirements:
1. Provide field engineering services. Utilize recognized engineering survey practices.
  2. Establish a minimum of four permanent bench marks on site, referenced to established control points. Record locations, with horizontal and vertical data, on project record documents.
  3. Establish elevations, lines and levels. Locate and lay out by instrumentation and similar appropriate means:
    - a. Site improvements including pavements; stakes for grading; utility locations, slopes, and invert elevations.
    - b. Grid or axis for structures of existing and new structures.
    - c. Column locations, ground floor elevations, and roof elevation of existing and new structure.
  4. Periodically verify layouts by same means.
- I. Existing Levels:
1. The Contractor shall satisfy himself that the levels as shown on the drawings are correct. Should the Contractor wish to dispute any levels he shall submit to the Engineer a schedule of the position of the levels considered to be in error and a set of revised levels. Levels shall not be disturbed during execution without the approval of the Engineer.
  2. Claims brought on discrepancies due to non compliance by the Contractor of the aforementioned shall not be considered.
- J. Tolerances: Survey tolerance shall be to agreed recognized standards in addition to the local relevant authorities' regulations and standards.

#### 1.4 REGULATORY REQUIREMENTS

- A. Scope: This Specification calls attention to the regulations to be observed by the Contractor and the Standards and Codes of Practice to which reference shall be made.
- B. Regulations:
1. The Contractor shall carry out the Works in full observance of the local authorities. Special attendance shall be also given to:
    - a. General Requirements, Site Administration, Safety, Health and Environmental Regulations.
    - b. Regulations and planning of the Municipality or local authority.
  2. All agencies and/or authorities involved to which a notice of intent should be declared and from which approvals should be obtained.
- C. Standards:
1. Notwithstanding the Specifications of certain Standards and Codes of Practice, all Materials, Products and Workmanship shall comply with the requirements of the latest edition of all relevant and current Standards, Standard Codes of Practice and all current amendments thereto.
  2. Compliance to be understood to mean that the standard attained shall not be less than that specified in the Standard or Code of Practice and may well be higher. In particular, where a higher standard is called for in the Specification that higher standard shall take precedence over the relevant Standard and Code of Practice, even if these are referred to in the text of the Specification.

3. In the case of materials and products which have been produced or manufactured in accordance with a published Standard or Code, that fact shall be brought to the attention of the Engineer together with full particulars of the standard in question which will be accepted by the Engineer if he is satisfied as to its provisions.

D. Industry Standards:

1. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents. Such standards are made a part of the Contract Documents by reference.
2. Publication Dates: Comply with standards in effect as of date of the Contract Documents, unless otherwise indicated.
3. Standards: Each entity engaged in construction on Project should be familiar with industry standards applicable to its construction activity. Applicable standards are not bound with the Contract Documents. Where such standards are specified, obtain these standards directly from available source.

## 1.5 MANAGEMENT AND ADMINISTRATION PROCEDURES

- A. General: Management shall be to agreed recognized standards or manuals.

B. Superintendence:

1. Accept responsibility for coordination, superintendence and administration of the Work including all works by sub-contractors and nominated sub-contractors.
2. Arrange and monitor a programme with each sub-Contractor, supplier and local authority and obtain and supply information as necessary for coordination of the Work.

- C. Sub-Contractor's Site Meeting: Hold meetings with appropriate sub-contractors and suppliers shortly before main site meetings to facilitate accurate reporting of progress.

D. Weather Record: Keep an accurate record of:

1. Daily maximum and minimum air temperature (including overnight)
2. Number of hours per day in which Work is prevented by inclement weather.
3. Weather Condition and Impact on Work Plant and Equipment.
4. Wind Speed and Wind Direction.

## 1.6 PROGRESS MEETINGS

- A. Schedule and administer meetings throughout progress of the Work at weekly intervals unless otherwise directed by the Engineer.

- B. Make arrangements for meetings in full coordination with the Engineer; prepare agenda with copies for participants, preside at meetings.

- C. Attendance Required: Contractor's Representative, major subcontractors and suppliers, Employer, and Engineer, as appropriate to agenda topics for each meeting.

- D. Agenda:
1. Review minutes of previous meetings.
  2. Review of Work progress.
  3. Field observations, problems and decisions.
  4. Identification of problems impeding planned progress.
  5. Review of submittals schedule and status of submittals.
  6. Review of off-site fabrication and delivery schedules.
  7. Maintenance of progress schedule.
  8. Corrective measures to regain projected schedules.
  9. Works executed during the last week.
  10. Works being executed this week.
  11. Planned activities and work progress during succeeding work period.
  12. Coordination of projected progress.
  13. Maintenance of quality and work standards.
  14. Effect of proposed changes on progress schedule and coordination.
  15. Site Safety.
  16. Site Clearance and Access to Work Location.
  17. Other business relating to Work.
- E. The Engineer will record minutes and distribute copies within two days after meeting to participants.

#### 1.7 PRE-INSTALLATION MEETINGS

- A. When required in individual specification sections, convene pre-installation meetings at Project site prior to commencing work of specific section.
- B. Require attendance of parties directly affecting, or affected by, Work of specific section.
- C. Notify the Engineer minimum four days in advance of meeting date.
- D. Prepare agenda and preside at meeting:
1. Review conditions of installation, preparation and installation procedures.
  2. Review coordination with related work.
- E. Record minutes and distribute copies within two days after meeting to participants, with two copies to Engineer, Employer and those affected by decisions made.

#### PART 2 PRODUCTS

Not Applicable.

#### PART 3 EXECUTION

Not Applicable.

END OF SECTION

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## SECTION 01323

### NETWORK ANALYSIS SCHEDULES

#### PART 1 GENERAL

##### 1.1 SECTION INCLUDES

- A. References.
- B. Quality assurance.
- C. Format.
- D. Construction Program.
- E. Submittals.
- F. Distribution.

##### 1.2 REFERENCES

- A. The Use of CPM in Construction: A Manual for General Contractors and the Construction Industry, Washington, D.C., The Associated General Contractors of America (AGC).
- B. CPM in Construction Management: Project Management with CPM, O'Brien, McGraw-Hill Book Company, New York.

##### 1.3 QUALITY ASSURANCE

- A. Scheduler: Contractor's personnel or Specialist Consultant specializing in CPM scheduling with ten years minimum experience in scheduling construction work of complexity comparable to this Project, and having use of computer facilities capable of delivering detailed graphic printout within 48 hours of request.
- B. Contractor's Administrative Personnel: Ten years minimum experience in using and monitoring CPM schedules on comparable projects.

##### 1.4 FORMAT

- A. Use latest edition of "Primavera Project Planner" for preparation of CPM schedule.
- B. Listings: Reading from left to right, in ascending order for each activity. Identify each activity with applicable specification section number.
- C. Diagram Sheet Size: 600 mm high x 900 mm wide or by the required width.
- D. Scale and Spacing: To allow for notations and revisions.
- E. Submit soft copies (Primavera Format) of schedule and all revisions and updates.

## 1.5 CONSTRUCTION PROGRAM

- A. The Contractor shall prepare a Construction Program showing the order and method in which he proposes to execute the works and the dates upon which the various elements, trades and sections of the works will be started and completed, including dates for submittal and approval of shop drawings and samples, for procurement and delivery of materials and equipment; for construction, installation, inspection, testing and commissioning.
- B. The construction program shall be in the form of Computerized Network Precedence Diagrams incorporating activities for all work to be performed by the Contractor, his Sub-Contractors and other Contractors to be employed in or about the site, supported by computer analysis and schedules and prepared in accordance with the principles of Critical Path Method (CPM) programming.
- C. The construction program shall be prepared by a qualified Network Analysis Consultant in collaboration with the Contractor. The Network Analysis Consultant shall be approved by Engineer and shall be skilled and experienced in construction programming of the kind specified for this project. The Network Analysis Consultant shall provide the Engineer access to his database for loading into the Engineer's computer system, whether by means of CDs or data-line communications.
- D. The network diagrams shall be clearly and accurately presented with work activities relating to specific locations or levels grouped for ease of reference. Each work activity shall have the following information shown in the diagram:
1. Activity Number.
  2. Concise Description of the Work.
  3. Specification Reference or Trade Code.
  4. Location of Work or Area Code.
  5. Duration in Calendar day.
- E. Computer Analysis:
1. In addition to the network diagrams the Contractor shall submit the following computer analysis output:
    - a. Activity Status Report.
    - b. Master Working Report: Chronological listing by early start of all activities and milestones.
    - c. Milestone Report: Chronological listing by early start of all milestones.
    - d. Contractor Reports: Individual report, sorted chronologically by early start, for each Sub-Contractor. These reports will only have the early start and early finish dates for distribution to Sub-Contractors.
    - e. Material Procurement Report: Based on the early start Construction Program, for all material items. This report shall include dates for submittal, approval release for ordering/fabrication, shipping and delivery to site.
    - f. Shop Drawings and Samples Reports: This schedule shall detail the dates for submission and approval of shop drawings and samples required by the Contract Documents, including those required from Sub-Contractors, and shall make due allowance for reasonable time of processing of shop drawings by the Engineer.

- g. Man Power Report: A listing of all activities displaying estimated crew sizes and manpower requirements for each activity.
          - h. Current Status Report: A listing of actual start and finish dates, activities already started and completed and percentage completion of activities still in progress.
          - i. Cash Flow Report: Showing projected monthly and cumulative expenditure.
        - 2. The activity status report shall have the following minimum data for each activity.
          - a. Activity Number.
          - b. Concise description of the work.
          - c. Specification reference or trade code.
          - d. Location of work or trade code.
          - e. Duration in calendar days.
          - f. Early start date (calendar).
          - g. Early finish date (calendar).
          - h. Late start date (calendar).
          - i. Late finish date (calendar).
          - j. Total float (calendar days).
          - k. Estimate crew size.
          - l. Percentage completion.
          - m. Remaining duration in calendar days.
- F. Supporting Data:
  - 1. The Contractor shall also prepare and submit in narrative form the supporting data noted below with the submittal of his Construction Program. Any changes in this information shall be submitted with successive updates and revision.
    - a. The proposed number of working days per week.
    - b. The holidays, and other non-working days observed during the duration of the Contract (by date).
    - c. The planned number of shifts per day.
    - d. The number of hours per shift.
    - e. The planned usage of major construction plant and equipment on the site, on a monthly basis.
    - f. The planned procurement and delivery of local and imported materials.
    - g. The average weekly manpower usage for each trade to be employed for the works.
    - h. The productivity rates for each major work sequence or for any specific activities required by the Engineer.
    - i. Explanation of all changes in logic, durations, manpower, plant and equipment.
    - j. Actual start and finish dates of activities already completed, and percentage completion of activities still in progress.
- G. Forty Five (45) Day Program: At monthly intervals, the Contractor shall submit a separate program developed from the approved Construction Program covering a period of forty five calendar days and denoting the Contractor's and Sub-Contractor's daily work activities and their interrelationship with the work of other Contractors, if any.

H. Construction Program Revisions and Updates

1. Once the initial Construction Program is submitted and approved by the Engineer, the Network Analysis Consultant shall perform monthly updates in collaboration with the Contractor. The update will follow a visit to the job site where in the presence of the Engineer, the Network Analysis Consultant and the Contractor will record the actual starts and percentages complete and, using this data, update the computer analysis. The updated analysis will be accompanied by a narrative report containing the supporting data referred to herein before, which shall indicate the necessary action dates and requirements for material, labour and plant acquisition. The narrative report shall also focus upon the construction progress and shall particularly note conditions that may delay progress of the work. In the event of such delays, the Contractor shall describe actions proposed to overcome the delay and to maintain the planned construction program.
2. Site Progress meetings attended by the Engineer, the Contractor, the Network Analysis Consultant and the principal Sub-Contractors, will be held monthly, immediately following the monthly site visit referred to in the previous paragraph, specifically to review the progress of the work. At this meeting the latest update of the last approved Construction Program will be examined with reference to the records made during the said site visit in order to verify the following:
  - a. Actual start and finish dates of activities completed during the period since the previous update or revision.
  - b. Remaining durations and percentage of completion for all activities in progress.
  - c. Logic, time and cost data for variation order work that will be incorporated into the Construction Program.
  - d. Contractor's measures to rectify delays from the planned dates.
3. The Contractor shall perform the work in accordance with the latest approved Construction Program. If any work is found not to be on program during any regular review of the work, the Contractor shall immediately advise the Engineer in writing of action proposed to bring the work back on program. The Contractor shall thereupon prepare and submit a revised Construction Program indicating such action, together with a list of revisions to program logic. Correction and updating of the program will be done as often as necessary until the project is back on program.
4. Within 5 working days after receipt of a notice from Engineer, the Contractor shall submit a revised Construction Program for any of the following reasons:
  - a. When delays in completion of any activity or group of activities indicates a slippage of the Contract completion date or a milestone date by fourteen (14) calendar days or ten percent (10%) of the remaining duration of the Contract period, whichever is less.
  - b. When delays in submittals or deliveries or work stoppage are encountered which make re-planning of the work necessary.
  - c. When the program does not represent the actual execution and progress of the work being performed in the field.
  - d. Where a change in the work sequence is proposed or has been instituted by the Contractor. Any such change should not, in any case, be made without the Engineer's approval.
  - e. Where the issue of a change order or other instruction would significantly affect the program and/or progress of the works.

5. In the event the Contractor requests an extension of time for completion of the works or requests an extension to the specified milestone dates, he shall furnish such justification and supporting data as the Engineer may deem necessary for the evaluation thereof. Submission of proper substantiation based on revised activity logic, durations and costs is obligatory with any such request.
6. Float belongs to the project and must be used in the best interest of completing the project on time. Accordingly, any existing float shall be used to the maximum extent possible to offset unexpected delays which occur in connection with the Contractor's work, acts of God (Force Majeur), and authorized variations in the scope of the work.

I. Programming Costs:

1. All costs in establishing, maintaining, revising and updating the construction program and related software shall be borne by the Contractor.

1.6 SUBMITTALS

- A. General Requirements: Submittal procedures.

1.7 DISTRIBUTION

- A. Following approvals of revisions and/or monthly updates to the Construction Program, distribute copies of updated schedules to Contractor's project site file, to Subcontractors, suppliers, Engineer, Employer, and other concerned parties.
- B. Instruct recipients to promptly report, in writing, problems anticipated by projections shown in schedules.

PART 2 PRODUCTS

Not Applicable.

PART 3 EXECUTION

Not Applicable.

END OF SECTION

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SECTION 01330  
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Scope.
- B. Definitions.
- C. Submittal Procedures.
- D. Engineer's Representative Review of Submittals.

1.2 SCOPE

- A. This section generally specifies procedures regarding submittals and the required submittals for the Contract. However, additional procedures and requirements for submittals are specified in individual sections of the specifications.
- B. Submittals shall include but not limited to the following:
  - 1. Submittal schedule.
  - 2. Coordination and sequencing.
  - 3. Submittal preparation and procedure.
  - 4. Product data.
  - 5. Construction program.
  - 6. Design by Contractor.
  - 7. Shop drawings and samples.
  - 8. Design data.
  - 9. Certificates.
  - 10. Test and inspection reports.
  - 11. Manufacturer's instructions.
  - 12. Manufacturer's field reports.
  - 13. Miscellaneous submittals.
  - 14. Site layout organization chart.
  - 15. Progress reports.
  - 16. Correspondence.
  - 17. CAD produced drawings.
  - 18. Photographs of construction progress.
- C. The list and schedule of all submittals and approvals should be compatible with the project schedule.
- D. The requirements of this section do not supersede or take precedence over any provision of the Conditions of Contract. Should any discrepancy become apparent between these requirements and the conditions of contract, the requirements of the conditions of contract shall prevail.

### 1.3 DEFINITIONS

- A. The work related to submittals of this section, in addition to the definitions of the conditions of Contract and elsewhere in the Contract Documents, are further categorized for convenience as follows:
1. Product data shall include manufacturer's latest standard printed literature such as manufacturer's installation instructions, catalog cuts, colour charts, roughing diagrams, wiring diagrams, and performance curves on materials, equipment and systems for this project. Product data shall include references to applicable specification section and item number. Product data shall be in addition to the required shop drawing submittals.
  2. Any design required by the Contractor, where called for in the Contract Documents, shall include all necessary calculations, working drawings and shop drawings.
  3. Construction Program shall be in the form of Computerized Network Precedence Diagrams incorporating activities for all work to be performed by the Contractor, his Sub-Contractors and other Sub-Contractors to be employed in or about the Site, supported by computer analysis and schedules and prepared in accordance with the principles of Critical Path Method Programming.
  4. Shop drawings shall include specially prepared technical data with diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, plans, sections, details and measurements in standard printed form (size A0 for drawings and Schedules, and size A4 for others). Shop drawings shall be in addition to the required product data and shall indicate applicable specification section and item numbers.
  5. Samples shall include physical examples of materials, both fabricated and unfabricated, in complete units and as smaller portions of units, for visual inspection and where stated, for more detailed testing and analysis. Samples shall indicate applicable section and item numbers within that section.
  6. Certificates shall include statements of suitability, certifying reports from governing agencies, industry standards and testing agencies and applicable certificates specified in each section of the specification.
  7. Test and inspection reports shall include reports specified to be required in each section of the specifications.
  8. Schedules shall include schedule of required submittals organized by related specification section number and sequence of submission, schedule of sequence of work and time schedule, schedule of sequence of application of specific units of work and schedule of materials, equipment and systems as listed in applicable sections of the specifications.
  9. Miscellaneous submittals shall include submittals related directly to the work (non-administrative) including warranties, maintenance agreements, workmanship bonds, survey data and reports, physical work records, copies of industry standards, record drawings, field measurement data, operating and maintenance materials, overrun stock, security/protection/safety keys and similar information, devices and materials applicable to the work and not processed as shop drawings, product data, samples or certificates.

## 1.4 SUBMITTAL PROCEDURES

### A. General:

1. Transmit each submittal with Engineer accepted form.
2. Sequentially number transmittal forms. Mark revised submittals with original number and sequential alphabetic suffix.
3. Identify Project, Contractor, Sub-Contractor and Supplier; pertinent drawing and detail number, and specification section number, appropriate to submittal.
4. Apply Contractor's stamp, signed or initialed certifying that review, approval, verification of products required, field dimensions, adjacent construction Work, and coordination of information are in accordance with requirements of the Work and Contract Documents.
5. Schedule submittals to expedite Project, and deliver to Engineer at business address. Coordinate submission of related items.
6. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of completed Work.
7. Allow space on submittals for Contractor and Engineer review stamps.
8. When revised for resubmission, identify changes made since previous submission.
9. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report inability to comply with requirements.
10. Submittals not requested will not be recognized or processed.

### B. Submittal Schedule:

1. All submittals and correspondence shall be submitted to the Engineer.
2. Any design required by the Contractor, where called for, shall be submitted to the Engineer for approval.
3. All shop drawings, material and samples submittal schedules shall be submitted to the Engineer for approval. In addition the Contractor shall submit Material delivery schedule for Engineer's approval. The Contractor shall adhere to the approved schedules.
4. Schedule submissions to ensure that the Engineer is allowed a reasonable time to review each submission within the scheduled period of time.
5. Certify that each submittal has been checked and approved by Sub-Contractors, installers, manufacturers and suppliers. Note any deviations from drawings or specifications.
6. No submissions shall be processed without signed & approved certification of Contractor. This certification shall be stated on each submission as follows:  
***Materials submitted for approval has been checked for conformance with drawings and specifications for this project. Any deviations from plans and specifications have been noted on the material or listed in the transmittal letter.***  
***Signed***

\_\_\_\_\_  
(Contractor)

### C. Coordination and Sequencing:

1. Coordinate preparation and processing of submittals with the Construction Program and progress so that the work will not be delayed.
2. Coordinate and sequence submittals for work and work interfaced with other work so that the processing of submittals will not be delayed by the lack of required coordination between submittals.

3. The obligation to coordinate the work indicated on any submittal material with other trades and with field conditions is the responsibility of the Contractor. No claim will be allowed for work that may have to be moved or replaced based on a claim that the work was placed in accordance with dimensions indicated on an approved submittal.
4. No claim for an extension of Contract Time will be granted because of Contractor's failure to coordinate submissions.

D. Submittal Preparation and Procedure:

1. The Contractor shall prepare and submit to the Engineer for approval any design required by the Contractor where called for, shop drawings including method statements, coordination drawings and final construction details, samples of materials, product data including data sheet and manufacturer's data, catalogues and specifications, and all other submittals stated hereinafter and required in each individual specification section.
2. Each submittal shall be accompanied by a "Transmittal" form whose format shall be to the approval of the Engineer and shall indicate the following:
  - a. Contract №: Contractor's name and job number.
  - b. Specification Section: The specification section number of item specified. (Do not submit items from more than one specification on the same form).
  - c. Submitted by: Name of Contractor's employee responsible for Contractor's review.
  - d. Contract Works Title: Name of Contract.
  - e. Transmittal №: Numbers shall be consecutive for the Works.
  - f. Date Submitted: Date on which any design by the Contractor where called for, shop drawings and sample leave Contractor's office.
  - g. Contractor: Name of firm preparing (and/or Supplier) original documents (any Design required by the Contractor where called for, Shop Drawings or Samples).
  - h. Submission №: 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, etc., depending on previous submission for same items (see re-submittal procedure).
  - i. Bill or Division: Item and description.
  - j. Specification Section Paragraph: Specific paragraph under which item is specified.
  - k. Copies and Type: Number of copies submitted and type of material submitted (print, brochure or sample, etc.).
  - l. Drawing №, Description and Date: Number of the Drawing. Title on the submission (where possible) and date on the submission. Where a group of related drawings are submitted as one unit, only one entry need to be made with a general description of what is included. (Drawings should then be numbered consecutively and have the same date).
  - m. Contractor's Remarks: Clearly note any exceptions or deviations from the Contract Documents and state reasons for them.
3. The Contractor shall plan the submission process in good time to meet the requirements of the program allowing for twenty one (21) days for engineering review and approval and for extra time for resubmission in the case of rejection. In all case he should plan to get the approval minimum thirty (30) days prior to the scheduled activity early start or the material purchase order.

4. Resubmission: Re-submittal procedures shall follow the same procedures as the initial submittal with the following exceptions:
    - a. Transmittal shall contain the same information as the first transmittal except that transmittal numbers shall run consecutively and the submission number shall indicate 2<sup>nd</sup>, 3<sup>rd</sup>, etc. submission. The drawing number/description shall be identical to the initial submission and the date shall be the revised date for that submission.
    - b. No new material shall be included on the same transmittal for a resubmission.
    - c. Once a sample, whether material or other, is submitted and approved then no alternative shall be submitted unless a valid and necessary reason is given to substantiate the submission of this alternative. Such reason shall be acceptable to the Engineer.
  5. Engineer's and Engineer's Representative Action on Transmittal Form: Incomplete or erroneous transmittals will be returned with directives indicated.
  6. Submittal Procedures by Contractor:
    - a. All correspondence and attachments thereto shall be submitted to the Engineer in one original and five copies and one digital/soft copy.
    - b. Six prints and one digital/soft copy of each shop drawing with transmittal forms shall be submitted to the Engineer's Representative.
    - c. Two samples of each material or prefabricated component with transmittal forms to the Engineer.
    - d. Six copies of brochures, one of which must be original, with transmittal forms to the Engineer.
- E. Product Data:
1. Within 14 days after Contract Implementation Commencement Date, submit list of major products proposed for use, with name of manufacturer, trade name, and model number of each product called for under "Submittals" in each individual specification section.
  2. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.
  3. Submit product data in triplicate for review. Indicate the actual materials being submitted for review when literature contains selections.
  4. Indicate product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- F. Construction Program (Specified in "Network Analysis Schedules" Section):
1. Program Submittal Procedures and Requirements:
    - a. The Contractor shall submit his initial Construction Program for approval, in four copies and one digital (Primavera Format) within 3 weeks of the Contract implementation commencement date, unless otherwise stated in the Conditions of Contract. Such initial Construction Program shall include the following completed documents:
      - 1) Network Precedence Diagram showing the sequence and interdependence of all items of work required under the Contract and milestone dates.
      - 2) All the computer analysis report required under this Contract.

- b. After approval of the Contractor's initial Construction Program, all subsequent revision and monthly update submittals shall comprise the following:
    - 1) Four (4) prints of the Network Diagrams from the last approved Construction Program, suitably marked up in red ink to show all revisions, and signed by the Contractor and all Sub-Contractors.
    - 2) Four (4) copies of the updated Activity Status Report.
    - 3) Four (4) copies of all supporting data.
    - 4) Four (4) copies of the master working report.
  - c. Revisions and monthly updates to the Construction Program shall be submitted within five (5) working days of the data date for inputting revised/updated information to create the revision/updated computer analysis. The data date for the first monthly update shall be one month after approval by the Engineer of the Contractor's initial Construction Program, and successive data dates shall be at monthly intervals. The said data date should coincide with the date of the site progress meeting at which time the records of progress are verified.
  - d. Each program submitted shall be signed by all principal Sub-Contractors including "Nominated" (if any) before being submitted to the Engineer thereby confirming that they have reviewed the said program. If any Sub-Contractor has reservations regarding his ability to comply with the program requirements to which he has appended his signature, the Contractor shall instruct the Sub-Contractor to list such reservations in writing and a copy thereof shall be submitted to the Engineer with the program submittal for his information. No reservation by any Sub-Contractor, nor the fact of informing the Engineer in respect thereof, shall relieve the Contractor of his responsibilities under the Contract in the time prescribed therein.
  - e. Submit a weekly report detailing the preparation, submittal and approval status of shop drawings, materials and equipment, samples and mock-ups and the status of materials and equipment procurement, order placed, delivery periods and site delivery dates.
2. Programming Costs:
    - a. All costs in establishing, maintaining, revising and updating the construction program shall be borne by the Contractor.
- G. Design by Contractor:
1. Any design required by the Contractor, where called for, together with all necessary calculations, working and shop drawings, shall be submitted to the Engineer within 15 days after Contract implementation commencement date.
  2. The design by Contractor, together with all necessary calculations, working drawings and shop drawings shall be prepared by the Contractor and by his principal Sub-Contractors for structural, architectural and electro-mechanical works, proper liaison and coordination between trades shall be attended to and ensured. Contractor shall also allow the Engineer's access for review and approval during the preparation process.
  3. The design by Contractor shall be prepared after site dimensions have been taken. Shop drawings shall be prepared on reproducible transparencies, and using metric units of measurement.

4. The Engineer's review and approval of any design required by the Contractor, is for general conformance with the design concept and specifications and shall not relieve the Contractor from responsibility for errors or omissions in respect of the requirements of any standards and codes.
  5. The Contractor shall make any corrections or amendments required by the Engineer's review of the design required by Contractor including calculations, working drawings and shop drawings, and shall resubmit until the "APPROVED" status is achieved. All such corrections or amendments shall be clearly indicated on the resubmitted design with all necessary calculations, working drawings and shop drawings, by the use of revision numbers in circles or triangles, or other method approved by the Engineer.
  6. No acceptance or approval by the Engineer of any design made by the Contractor, nor any notes, comments, stipulations, requests for clarifications, etc., made by the Engineer upon such submissions during his review and approval thereof, shall constitute an authorization to any variation in the Contract price or to any extra time for completion of the works.
- H. Shop Drawings and Samples: Shop drawings shall establish actual details of manufactured/fabricated items and of work to be executed; they shall clearly identify materials, dimensions, thicknesses, components, attachments, relation with adjoining work and spaces, and all other pertinent information; they shall clarify & amplify the design drawings and other design requirements and shall, subject to the Engineer's approval, incorporate minor changes in design or construction as may be necessary or otherwise desirable to suit the requirements of the work. Where the Contract Documents require the Contractor to submit samples, the same shall satisfactorily establish that the quality, construction, workmanship, finish, color, pattern and any other characteristics of the material or equipment to be provided, are in conformance with the Contract requirements and to the Engineer's reasonable satisfaction.
1. The Contractor shall prepare, review, coordinate and submit to the Engineer for his approval such shop drawings and samples as required by the Contract Documents or as may be required by Engineer during the course of works.
  2. At the time of making his submission, the Contractor shall inform the Engineer in writing of any deviation between shop drawings and/or samples being submitted and the requirements stipulated or reasonably implied by the Contract Documents.
  3. By submitting shop drawings and samples, the Contractor thereby represents that he has determined and verified all dimensions, relation to existing work, coordination with the work to be installed later, coordination with information in previously submitted shop drawings, and has verified their compliance with the requirements of the Contract Documents. The accuracy of all such information is the responsibility of the Contractor and in reviewing shop drawings and samples, the Engineer shall be entitled to rely upon the Contractor's representation that such information is correct and accurate. The Contractor shall be responsible for and shall make any alterations in the work due to discrepancies, errors or omissions provided that such discrepancies, errors or omissions are not due to incorrect information contained in the Contract Documents or due to inaccurate information furnished to the Contractor in writing by the Engineer. The Contractor shall be responsible for the correct locations of his work, irrespective of approval by the Engineer, and shall pay all costs and expenses incurred by others due to improper location of his work.

4. Sub-Contractors shall submit their shop drawings and samples through the Contractor who shall review and coordinate with his own and other Sub-Contractor's drawings and/or samples before submitting to the Engineer. The Contractor shall be responsible in all respects for his Sub-Contractor's shop drawings and samples as if they were his own.
5. Neither the fabrication of prefabricated items, nor the ordering of any work, materials or equipment, nor the execution of any work on site, shall commence until shop drawings and samples, relevant to the said items, work, etc., and required by the specifications, have been submitted and approved in writing by the Engineer.
6. Shop drawings shall be prepared by the Contractor and by his principal Sub-Contractors for structural, architectural and electro-mechanical works, proper liaison and coordination between trades shall be attended to and ensured. Contractor shall also allow the Engineer's access for review and approval during the preparation process.
7. Shop drawings and samples shall be prepared after site dimensions have, if possible, been taken. Shop drawings shall be prepared on reproducible transparencies, and using metric units of measurement.
8. Shop drawings shall describe accurately the method of fabrication, installation, applied finishes, types and sizes of all members and fixings, and shall, where applicable, indicate methods of marking components for site erection. Shop drawings shall be to scales approved by the Engineer.
9. The Contractor shall verify all dimensions and field conditions and shall check and coordinate the shop drawings and samples required in connection with a particular trade or section of the works with the requirements of other trades or section related thereto.
10. In order to ensure proper coordination, shop drawings and samples for each system or element of work shall be submitted in a single package. The Engineer may require in writing that all relevant parts of a system or element be submitted before any component item is approved.
11. Approval by the Engineer shall neither relieve the Contractor of any of his responsibilities under the Contract, nor constitute authorization of any change to the Contract Documents.
12. Except for finish, pattern, color and other matters in respect of which the Engineer's decision is required in accordance with the Contract Documents, the Engineer's review and approval of shop drawings and samples submitted by the Contractor is for general conformance with the design concept and specifications, and shall not relieve the Contractor from responsibility for any deviation from, or errors or omissions in respect of the Contract Documents requirements, unless the Contractor has informed the Engineer in writing of specific deviations and the Engineer has given written approval thereto.
13. In event of written rejection by Engineer to any shop drawing, the Contractor shall resubmit within fourteen (14) days of such rejection, the revised shop drawings for Engineer's approval. This procedure shall be repeated until such time the shop drawing is approved by Engineer. The Engineer approval shall not relieve the Contractor from any of his obligations under the Contract.
14. The Contractor shall make any corrections or amendments required by the Engineer's review of shop drawings and samples, and shall resubmit until the "Approved" status is achieved. All such corrections/amendments to be clearly indicated on the resubmitted drawings and samples by the use of revision numbers in circles or triangles, or other method approved by the Engineer.

15. The Contractor shall direct specific attention in writing or resubmitted shop drawings and samples to revisions other than the corrections requested by the Engineer or previous submissions. Unless such written notice has been given, approval of a resubmitted shop drawing or sample shall not constitute approval of any changes not requested on the prior submission.
  16. In the event of written rejection by the Engineer to a particular sample of material, the Contractor shall submit within fourteen (14) days of such rejection, samples of three alternative materials for the Engineer's approval and the Engineer shall reject or approve all or any of these materials within fourteen (14) days of their submission. This procedure shall be repeated until such time as a sample of material is approved by the Engineer. Failure on the part of the Contractor to obtain the Engineer's approval, which shall not be withheld unreasonably, to all or any one sample or material shall in no way relieve the Contractor of his liabilities and obligations under the Contract.
  17. The Engineer may at any time call upon the Contractor to submit samples of any material used or to be used in the work, including those specified in the Contract by "Brand Name", for comparison with the specification and/or approved sample. Should any such sample fail to meet the requirements of the specification and/or standard of the accepted sample, then all materials from which the sample has been taken shall be removed from the site immediately and all work executed incorporating such material shall be removed and made good to the satisfaction of the Engineer all at the expense of the Contractor.
  18. No acceptance or approval by the Engineer of any shop drawing or sample submission made by the Contractor, nor any notes, comments, stipulations, requests for clarifications, etc., made by the Engineer upon such submissions during his review and approval thereof, shall constitute an authorization to any variation in the Contract price or to any extra time for completion of the works.
- I. Design Data:
1. Submit for Engineer's knowledge as contract administrator or for Employer.
  2. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.
- J. Certificates:
1. When specified in any specification section under "Submittals", submit certification by manufacturer, installation or application sub-contractor, or Contractor to Engineer, in quantities specified for Product Data.
  2. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
  3. Certificates may be recent or previous test results on material or Product, but must be acceptable to the Engineer.
  4. Submit certificates in triplicate for review.
- K. Test and Inspection Reports:
1. Submit test and inspection reports called for in each specification section.
  2. Submit test reports for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

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- L. Manufacturer's Instructions:
1. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Engineer for delivery to Employer in quantities specified for Product Data.
  2. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.
- M. Manufacturer's Field Reports:
1. Submit reports for Engineer's benefit.
  2. Submit report in duplicate within 14 days of observation to Engineer for information.
  3. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.
- N. Miscellaneous Submittals:
1. Refer to each individual specification section and the Contract Documents for additional submittal requirements.
- O. Site Layout Organization Chart:
1. The Contractor shall prepare and submit to the Engineer's Representative for his approval, a site layout organization plan, and any modifications thereafter showing the Contractor's proposed layout of his temporary construction facilities and controls, and his plant and equipment on site.
- P. Progress Reports:
1. Monthly Progress Reports: The Contractor shall submit to the Engineer each month a progress report showing the actual progress of work by identifying activities and works commenced and/or completed during the previous month with progress photographs, activities and works to be carried out during the following month, and the estimated time required to complete all activities and works in relation to the programme of works. Such reports shall be to the satisfaction of the Engineer.
  2. Daily/Weekly Progress Reports: To be provided for the work required, if any, where expressly stated in its related specification section.
- Q. Correspondence: Except where more are required by the contract, all correspondence shall be through the Engineer, and shall be submitted as follows:
1. One original and two photocopies of transmittals and letters including attachments/enclosures.
- R. CAD Produced Drawings:
1. The Contractor shall prepare his shop drawings, progress record drawings, and final as-built drawings using computer aided design and drafting techniques (CAD).
  2. All computer hardware, software and computer room necessary for the preparation of drawings using CAD shall be provided by the Contractor at no additional cost.
  3. Data indicating inappropriate or unacceptable Work may be subject to action by Engineer or Employer.

- S. Photographs of Construction Progress:
1. During the progress of the work, submit in triplicate, colored photographs taken one a month by an approved professional photographer consisting of 20 views, all taken where directed by the Engineer. Prints shall be 130 x 180 mm matt finish, unless otherwise stated in the Conditions of Contract.
  2. At the completion of all work final photographs shall be taken as directed by the Engineer.
  3. Identify each print on back. Identify Name of Project, Contract Number, orientation of view, date and time of view, name and address of photographer, and photographer's numbered identification of exposure.
  4. All negatives or soft copies in case of digital camera shall be delivered to the Employer in their proper order, and shall become the Employer's property. Include typed table of contents of all photographs in chronological sequence.
  5. The Contractor shall submit photographs for all works to be covered before covering such works to the approval of the Engineer.
- T. Penalty for Delays in Submittal of any Document or Schedule: The Engineer may, following written notice to the Contractor, deduct from payments to the Contractor an amount of money as a penalty for each delay in Submittal of any Document or Schedule (minimum 200 US \$ per calendar day per document or per schedule).

#### 1.5 ENGINEER'S REPRESENTATIVE REVIEW OF SUBMITTALS

- A. The Engineer's Representative will process the submission and indicate the appropriate action on the submission and the transmittal, and will note major deviations from the Engineer's Contract Documents or reasons for resubmit if there are not notes on the material submitted.

#### PART 2 PRODUCTS

Not Applicable.

#### PART 3 EXECUTION

Not Applicable.

END OF SECTION

SECTION 01400  
QUALITY REQUIREMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Quality control and control of installation.
- B. Tolerances.
- C. References.
- D. Mock-up requirements.
- E. Testing and inspection services.
- F. Manufacturers' field services.
- G. Examination.
- H. Preparation.

1.2 QUALITY CONTROL AND CONTROL OF INSTALLATION

- A. The Contractor shall submit Quality Assurance Program consisting of the Quality Assurance Manual, Project Quality Assurance Plan. Such program shall be subject to the Engineer's approval.
- B. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.
- C. Comply with manufacturers' instructions, including each step in sequence. When manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.
- D. Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Perform Work by persons qualified to produce required and specified quality.
- F. Verify field measurements are as indicated on shop drawings or as instructed by manufacturer.
- G. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

### 1.3 TOLERANCES

- A. Monitor fabrication and installation tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.
- B. Comply with manufacturers' tolerances. When manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.
- C. Adjust products to appropriate dimensions; locate before securing products in place.

### 1.4 REFERENCES

- A. Whenever specific standards, brands, trades, etc. are mentioned, equivalent equal are acceptable without stating "or equivalent" each time.
- B. For products or workmanship specified by association, trades, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.
- C. Conform to reference standard by date of issue current on date of Contract Documents, except where a specific date is established by code.
- D. Obtain copies of standards where required by product specification sections.
- E. When specified reference standards conflict with Contract Documents, request clarification from the Engineer before proceeding.
- F. Neither the contractual relationships, duties, responsibilities of the parties in Contract, nor those of the Engineer shall be altered from the Contract Documents by mention or inference otherwise in any reference documents.

### 1.5 MOCK-UP REQUIREMENTS

- A. Tests will be performed under provisions identified in this section and identified in the respective product specification sections.
- B. Assemble and erect specified items with specified attachment and anchorage devices, flashings, seals and finishes.
- C. Accepted mock-ups shall be comparison standard for the remaining Work.
- D. Where mock-up has been accepted by Engineer and is specified in product specification sections to be removed; remove mock-up and clear area when directed to do so by Engineer.
- E. Submit drawings showing location and details of Mockup plus a description report of Mockup.
- F. Submit test certificates for tests to be undertaken.
- G. Testing operations may include, but not limited to, weather tests, seismic, water, air, wind resistance, permeability and load safety.

- H. Submit test reports for Visual and Tests of Mockups: Indicate substantiating engineering data, test results of previous tests by independent laboratory which purport to meet performance criteria and other supportive data.

## 1.6 TESTING AND INSPECTION SERVICES

### A. Scope:

1. This section covers testing services including selection and payment, contractor submittals, agency responsibilities, agency reports, limits on testing authority, Contractor responsibilities and schedule of tests.
2. Employment and payment for services of an independent testing agency or laboratory to perform specified testing shall be borne by the Contractor.
3. Employment of testing agency or laboratory in no way relieves Contractor's obligation to perform Work in accordance with the requirements of the Contract Documents.

### B. Performance and Standards:

1. ASTM C802: Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods for Construction.
2. ASTM C1021: Practice for Laboratories Engaged in the Testing of Building Sealants.
3. ASTM C1077: Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.
4. ASTM C1093: Practice for Accreditation of Testing Agencies for Unit Masonry.
5. ASTM E329: Practice for Use in the Evaluation of Inspection and Testing Agencies as Used in Construction.
6. ASTM E543: Practice for Determining the Qualification of Nondestructive Testing Agencies.
7. ASTM E548: Practice for Preparation of Criteria for Use in the Evaluation of Testing Laboratories and Inspection Bodies.
8. ASTM E699: Practice for Criteria for Evaluation of Agencies Involved in Testing, and Evaluating Building Components in Accordance with Test Methods Promulgated by ASTM Committee E6.
9. ASTM E779: Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.

### C. Submittals:

1. Prior to start of Work, submit testing laboratory name, address, and telephone number and names of full time specialist and responsible officer to the Engineer for approval.
2. Submit copy of report of laboratory facilities inspection made, with memorandum of remedies of any deficiencies reported by the inspection.

### D. The independent firm will perform tests, inspections and other services specified in individual specification sections and as required by the Engineer.

1. Laboratory: Authorized to operate at Project location.
2. Laboratory Staff: Maintain full time registered Engineer or specialist on staff to review services.

3. Testing Equipment: Calibrated at reasonable intervals with devices of accuracy traceable to National Bureau of Standards or accepted values of natural physical constants.
- E. Testing, inspections and source quality control may occur on or off project site. Perform off-site testing as required by the Engineer or Employer.
- F. Reports will be submitted by independent firm to the Engineer and Contractor, in duplicate, indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents.
- G. Cooperate with independent firm; furnish samples of materials, design mix, equipment, tools, storage, safe access, and assistance by incidental labor as requested.
  1. Notify the Engineer and the independent firm 24 hours prior to expected time for operations requiring services.
  2. Make arrangements with independent firm and pay for additional samples and tests required for Contractor's use.
- H. Testing and employment of testing agency or laboratory shall not relieve the Contractor of obligation to perform Work in accordance with requirements of Contract Documents.
- I. Re-testing or re-inspection required because of non-conformance to specified requirements shall be performed by same independent firm on instructions by the Engineer. Payment for re-testing or re-inspection will be charged to Contractor by deducting testing charges from Contract Sum/Price.
- J. Agency Responsibilities:
  1. Test samples of mixes submitted by Contractor.
  2. Provide qualified personnel at site. Cooperate with Engineer and Contractor in performance of services.
  3. Perform specified sampling and testing of Products in accordance with specified standards.
  4. Ascertain compliance of materials and mixes with requirements of Contract Documents.
  5. Promptly notify Engineer and Contractor of observed irregularities or non-conformance of Work or Products.
  6. Perform additional tests required by Engineer.
  7. Attend preconstruction meetings and progress meetings.
- K. Agency Reports:
  1. After each test, promptly submit four copies of report to Engineer and to Contractor.
  2. Include the following:
    - a. Date issued.
    - b. Project title and number.
    - c. Name of inspector.
    - d. Date and time of sampling or inspection.
    - e. Identification of product and specifications section.
    - f. Location in Project.
    - g. Type of inspection or test.

- h. Date of test.
      - i. Results of tests.
      - j. Conformance with Contract Documents.
    - 3. When requested by Engineer, provide interpretation of test results.
- L. Limits on Testing Authority:
  - 1. Agency or laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
  - 2. Agency or laboratory may not approve or accept any portion of the Work.
  - 3. Agency or laboratory may not assume duties of Contractor.
  - 4. Agency or laboratory has no authority to stop the Work.
- M. Contractor's Responsibilities:
  - 1. Deliver to agency or laboratory at designated location, adequate samples of materials proposed to be used which require testing, along with proposed mix designs.
  - 2. Cooperate with laboratory personnel, and provide access to the Work and to manufacturer's facilities.
  - 3. Provide incidental labor and facilities:
    - a. To provide access to Work to be tested.
    - b. To obtain and handle samples at the site or at source of Products to be tested.
    - c. To facilitate tests.
    - d. To provide storage and curing of test samples.
  - 4. Notify Engineer and laboratory 36 hours prior to expected time for operations requiring testing services.
- N. Schedule of Tests:
  - 1. Individual Specification Section: Tests required and standards for testing.

#### 1.7 MANUFACTURERS' FIELD SERVICES

- A. When specified in individual specification sections, require material or product suppliers or manufacturers to provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment, test and adjust and balance of equipment as applicable, and to initiate instructions when necessary.
- B. Submit qualifications with CV of observer to the Engineer, thirty (30) days in advance of required observations. The Observer shall be subject to the approval of the Engineer.
- C. Report observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

#### PART 2 PRODUCTS

Not Applicable.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Verify that existing site conditions and substrate surfaces are acceptable for subsequent Work. Beginning any new Work, means acceptance of existing conditions.
- B. Verify that existing substrate is capable of structural support or attachment of new Work being applied or attached.
- C. Examine and verify specific conditions described in individual specification sections.
- D. Verify that utility services are available, of correct characteristics and in the correct locations.

### 3.2 PREPARATION

- A. Clean substrate surfaces prior to applying next material or substance.
- B. Seal cracks or openings of substrate prior to applying next material or substance.
- C. Apply manufacturer required or recommended substrate primer, sealer, or conditioner prior to applying any new material or substance in contact or bond.

END OF SECTION

## SECTION 01500

### CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

#### PART 1 GENERAL

##### 1.1 SCOPE

- A. Section includes provision, maintenance during Contract implementation and removal at the end of the entire project of the following:
1. Temporary Utilities: Electricity, lighting for construction purposes, site lighting, heating, cooling, ventilation, telephone service, facsimile service, water service, and sanitary facilities.
  2. Temporary Controls: Barriers, enclosures, fences and gates, security, traffic safety and regulation, water control, dust control, erosion and sediment control, noise control, pest control, pollution control, rodent control, and first aid facilities.
  3. Construction Facilities: Parking, progress cleaning and waste removal, project identification, field offices and sheds, vehicles, vehicular access, plant and small tools, and scaffolding and hoisting.

##### 1.2 PERFORMANCE AND STANDARDS

- A. The Contractor shall abide fully by the provisions and requirements of all regulations imposed by relevant authorities having jurisdiction, which include, but not limited to, all requirements, site administration and regulations, safety, health and environmental regulations, and regulation and planning of the project location with its sectors.
- B. The Contractor shall take all precautions necessary to protect persons and property on or off site from injury or damage resulting from work under this Contract.
- C. Failure to comply with any of the regulations or requirements shall be considered a breach of Contract by the Contractor and may result in termination of the Contract by the Employer. Nevertheless, should the Contractor fail to comply with such:
1. The Engineer may suspend the Works or part of the Works until the Contractor has taken necessary steps, to the satisfaction of the Engineer, to comply with the regulations or requirements.
  2. The Engineer may suspend any interim payment certificate until such time as the Contractor has rectified the breach or breaches to the satisfaction of the Engineer. No interest shall be paid on the suspended payments.
  3. The Employer may, following written notice to the Contractor, carry out himself or arrange for another contractor to carry out such measures as he considers appropriate on behalf of the Contractor. Any such actions by the Employer shall not affect or diminish the Contractor's obligations or responsibilities under the Contract.
  4. The Engineer may, following written notice to the Contractor, deduct from payments to the Contractor an amount of money as a penalty for each breach of any regulation or requirement. Such notice shall specify the nature of the failure or failures, and the period after the date of the notice within which the Contractor shall remedy each failure.

- D. In the event of the Employer or Engineer taking action based on the above, the Contractor shall not be entitled to any additional costs or extension to the Contract Completion Date.
- E. All costs incurred by the Employer pursuant to the above, and the deductions from payments imposed on the Contractor by the Engineer shall be deducted from amounts otherwise due to the Contractor.

### 1.3 RELATED ITEMS

- A. General Requirements: Contractor's use of site, administrative requirements for field engineering, and execution requirements for cleaning.

### 1.4 STANDARDS AND REGULATIONS

- A. In addition to what is stated in this specification section, all temporary utilities, temporary controls and construction facilities shall comply with relevant authorities' standards and regulations for "Site Administration and Rules", "Safety, Health and Environmental Regulations", and all other local authorities' standards and regulations.
- B. Moreover, the Contractor is responsible to perform all the necessary process, regarding all temporary services, with all relevant authorities, and shall pay all installation and maintenance fees.

### 1.5 ELECTRICITY

- A. Provide, maintain and pay for power service required for the works from time of project mobilization until handing over.
- B. Provide power outlets for construction operations, with branch wiring and distribution boxes located as required.
- C. Provide main service disconnect and over-current protection at convenient location.
- D. Permanent convenience receptacles may not be utilized during construction.
- E. Provide adequate distribution equipment, wiring and outlets to provide single phase branch circuits for power and lighting.
  - 1. Provide 20 ampere duplex outlets, single phase circuits for power tools for each active work area.
  - 2. Provide 20 ampere, single phase branch circuits for lighting.

### 1.6 LIGHTING FOR CONSTRUCTION PURPOSES

- A. Provide and maintain incandescent lighting for construction operations to achieve acceptable lighting level.
- B. Provide and maintain lighting to exterior staging and storage areas after dark for security purposes.
- C. Provide and maintain lighting to interior work areas after dark for security purposes.

- D. Provide branch wiring from power source to distribution boxes with lighting conductors, pigtails and lamps as required.
- E. Maintain lighting and provide routine repairs.
- F. Permanent lighting shall not be utilized during construction.

#### 1.7 SITE LIGHTING

- A. The Contractor shall install temporary site lighting including but not restricted to perimeter fence, name boards, parking areas and for site safety to the satisfaction of the Engineer and the approval of Statutory Authorities.

#### 1.8 HEATING

- A. Existing facilities, if any, shall not be used, unless otherwise directed by the Engineer.
- B. Provide and pay for heating devices and heat as needed to maintain specified conditions for construction operations.
- C. Prior to operation of permanent equipment for temporary heating purposes, verify installation is approved for operation, equipment is lubricated and filters are in place. Provide and pay for operation, maintenance, and regular replacement of filters and worn or consumed parts.
- D. Unless otherwise directed by the Engineer or indicated in "Product" part in each individual specification sections, maintain minimum ambient temperature of 10°C in areas where construction is in progress.

#### 1.9 COOLING

- A. Existing facilities, if any, shall not be used, unless otherwise directed by the Engineer.
- B. Provide and pay for cooling devices and cooling as needed to maintain specified conditions for construction operations.
- C. Prior to operation of permanent equipment for temporary cooling purposes, verify installation is approved for operation, equipment is lubricated and filters are in place. Provide and pay for operation, maintenance, and regular replacement of filters and worn or consumed parts.

#### 1.10 VENTILATION

- A. Ventilate enclosed areas to achieve curing of materials, to dissipate humidity, and to prevent accumulation of dust, fumes, vapors, or gases.
- B. Reduce the emission of gas to the satisfaction of the Engineer.

#### 1.11 TELEPHONE SERVICE

- A. Provide, maintain and pay for telephone service to field office and Engineer's field office from time of project mobilization until completion of the works.

#### 1.12 FACSIMILE SERVICE

- A. Provide, maintain and pay for facsimile service and dedicated telephone line to field office and Engineer's field office from time of project mobilization until completion of the works.

#### 1.13 WATER SERVICE

- A. Provide, maintain and pay for suitable quality water service required for construction operations and all purposes from time of project mobilization until completion of the works.
- B. Extend branch piping with outlets located so water is available by hoses with threaded connections.
- C. Make available clean and hygiene potable water for the use of personnel on site.
- D. Test to BS 3148 when instructed.

#### 1.14 SANITARY FACILITIES

- A. Provide and maintain required facilities and enclosures. Provide from time of project mobilization until completion of the works.
- B. Sanitary facilities include temporary well aerated toilets, wash facilities and drinking-water fixtures. Comply with regulations and health codes for the type, number, location, operation, and maintenance of fixtures and facilities.
  - 1. Provide toilet tissue, paper towels, paper cups and similar disposable materials for each facility.
  - 2. Provide covered waste containers for used material.
  - 3. Use of the Employer's toilet facilities will not be permitted.
  - 4. Install self-contained toilet units. Shield toilets to ensure privacy Use of pit-type privies will not be permitted.
  - 5. Provide separate facilities for male and female personnel.
  - 6. Provide proper sanitation by connecting to the main sewage system.

#### 1.15 BARRIERS

- A. Provide barriers to prevent unauthorized entry to construction areas and to protect facilities and adjacent properties from damage from construction operations.
- B. Provide barricades and covered walkways required by governing authorities for public rights-of-way and for public access to any existing adjacent property.
- C. Protect non-owned vehicular traffic, stored materials, site and structures from damage.
- D. Provide protection for plants designated to remain. Replace damaged plants.

## 1.16 ENCLOSURES

- A. Exterior Enclosures:
  - 1. Provide temporary scaffolding with approved screens to safeguard the public from dust and fallout as per Engineer Requirement.
  - 2. Provide temporary insulated weather tight closure of exterior openings to accommodate acceptable working conditions and protection for products, to allow for temporary heating and maintenance of required ambient temperatures identified in individual specification sections, and to prevent entry of unauthorized persons. Provide access doors with self-closing hardware and locks.
  - 3. Provide temporary roofing to the satisfaction of the Engineer.
- B. Interior Enclosures:
  - 1. Provide temporary partitions and ceilings as directed and to the satisfaction of the Engineer, to separate work areas from Employer occupied areas, to prevent penetration of dust and moisture into Employer occupied areas, and to prevent damage to finished and completed work.
  - 2. Construction: Framing and reinforced polyethylene, plywood or gypsum board sheet materials with closed joints and sealed edges at intersections with existing surfaces:
    - a. Insulated to RSI Standards.
    - b. STC rating of 35 in accordance with ASTM E90.
    - c. Maximum flame spread rating of 25 in accordance with ASTM E84.
  - 3. Paint surfaces exposed to view from Employer occupied areas.

## 1.17 FENCES AND GATES

- A. Maintain the site from unauthorized entrant by providing all necessary temporary fences and gates around and within the site.
- B. Maintain electrical fixtures including wires, boxes, lamps and switches as directed by the Engineer.
- C. Maintain fencing, gates and other temporary items as long as required for safe and proper completion of work, promptly repair or replace in the event of loss or damage.
- D. Design fences and gates to withstand 160 km/hr wind velocity. All materials shall be of adequate strength, suitable for use intended, non-staining and non-corrosive.
- E. Upon completion of the works, remove fences and gates to areas indicated by the Employer and make good the area to the satisfaction of the Engineer.

## 1.18 SECURITY

- A. Security Program:
  - 1. Protect Work, existing premises and Employer's operations from theft, vandalism and unauthorized entry.
  - 2. Initiate program at project mobilization.
  - 3. Maintain program throughout construction period until Employer occupancy or when directed by the Engineer.

- B. Entry Control:
  - 1. Restrict entrance of persons and vehicles into Project site and facilities.
  - 2. Allow entrance only to authorized persons with proper identification.
  - 3. Maintain log of workers and visitors, make available to Employer on request.
  - 4. Control entrance of persons and vehicles related to Employer's operations.
- C. Personnel Identification:
  - 1. Provide identification badge to each person authorized to enter premises.
  - 2. Badge to Include: Personal photograph, name and assigned number, Contractor name, and Sub-Contractor name (if any).
  - 3. Maintain list of accredited persons, submit copy to Employer on request.
  - 4. Require return of badges at expiration of their employment on the Work.
- D. Security Service: Employ uniformed guard service to provide watchpersons at site twenty-four hours a day, seven days a week.
- E. Restrictions: Do not allow cameras on site or photographs taken except by written approval of Employer.

#### 1.19 TRAFFIC SAFETY AND REGULATION

- A. General:
  - 1. The Contractor shall provide, erect and maintain such traffic signs, traffic control signals and such other measures as may be required by the Construction of the Works to the satisfaction of the Engineer.
  - 2. The Contractor shall not commence any work which affects public roads until all the traffic safety measures necessitated by the work are fully operational.
  - 3. The Contractor shall keep clean and legible at all times all traffic signs, lamps, barriers and traffic control signals and he shall position, cover or remove them as required by the progress of the Works.
- B. Signs, Signals and Devices:
  - 1. Post Mounted and Wall Mounted Traffic Control and Informational Signs: As approved by authority having jurisdiction.
  - 2. Traffic Control Signals: As approved by local jurisdictions.
  - 3. Traffic Cones and Drums, Flares and Lights: As approved by authority having jurisdiction.
  - 4. Flag Person Equipment: As required by authority having jurisdiction.
- C. Traffic Signs and Signals:
  - 1. Provide signs at approaches to site, on site, at crossroads, detours, parking areas and elsewhere as needed to direct construction and affected public traffic.
  - 2. Provide, operate and maintain traffic control signals to direct and maintain orderly flow of traffic in areas under Contractor's control and areas affected by Contractor's operations.
  - 3. Relocate as Work progresses, to maintain effective traffic control.
- D. Flag Persons: Provide trained and equipped flag persons to regulate traffic when construction operations or traffic encroach on public traffic lanes.

- E. Flares and Lights: Use flares and lights during hours of low visibility to delineate traffic lanes and to guide traffic.
- F. Haul Routes:
  - 1. Consult with authority having jurisdiction, establish public thoroughfares to be used for haul routes and site access.
  - 2. Confine construction traffic to designated haul routes.
  - 3. Provide traffic control at critical areas of haul routes to regulate traffic and to minimize interference with public traffic.
- G. Mud:
  - 1. The wheels of all vehicles shall be well washed before being allowed to leave the Site; lay-down area or any other area which the Contractor is utilizing for the purposes of this Contract.
  - 2. Any mud, which is deposited outside the site boundary, is to be removed immediately, and the whole area shall be thoroughly cleaned.
- H. Removal:
  - 1. Remove equipment and devices at Substantial Completion or when directed by the Engineer.
  - 2. Remove post settings to depth of 600 mm.
  - 3. Repair damage caused by installation.

#### 1.20 WATER CONTROL

- A. Grade site to drain. Maintain excavations free of water. Provide, operate and maintain pumping equipment.
- B. Protect site from puddling or running water.

#### 1.21 DUST CONTROL

- A. Execute Work by methods to minimize raising dust from construction operations.
- B. Provide positive means to prevent air-borne dust from dispersing into atmosphere.

#### 1.22 EROSION AND SEDIMENT CONTROL

- A. Plan and execute construction by methods to control surface drainage from cuts and fills, from borrow and waste disposal areas. Prevent erosion and sedimentation.
- B. Minimize surface area of bare soil exposed at one time.
- C. Provide temporary measures including berms, dikes and drains, and other devices to prevent water flow.
- D. Construct fill and waste areas by selective placement to avoid erosive surface silts or clays.
- E. Periodically inspect earthwork to detect evidence of erosion and sedimentation; promptly apply corrective measures.

1.23 NOISE CONTROL

- A. Provide methods, means and facilities to minimize noise produced by construction operations. Provide sound reducers as necessary to the satisfaction of the Engineer.

1.24 PEST CONTROL

- A. Provide methods, means and facilities to prevent pests and insects from damaging the Work and entering facility.

1.25 POLLUTION CONTROL

- A. Provide methods, means and facilities to prevent contamination of soil, water and atmosphere from discharge of noxious, toxic substances and pollutants produced by construction operations.
- B. Comply with pollution and environmental control requirements of authorities having jurisdiction.

1.26 RODENT CONTROL

- A. Provide methods, means and facilities to prevent rodents from accessing or invading premises.

1.27 FIRST AID FACILITIES

- A. The Contractor shall provide and maintain on site first aid facilities throughout the Contract period to the approval of the Engineer.

1.28 PARKING

- A. Construct temporary paved surface covered parking areas to accommodate Employer, Engineer and Supervision Consultant personnel. Do not use these designated areas of parking facilities used by Employer, Engineer and Supervision Consultant personnel.
- B. Locate as indicated on Drawings or as approved by the Engineer.
- C. When site space is not adequate, provide additional off-site parking.
- D. Use of designated existing on-site streets and driveways used for construction traffic is not permitted. Tracked vehicles not allowed on paved areas.
- E. Do not allow heavy vehicles or construction equipment in parking areas.
- F. Do not allow vehicle parking on existing pavement.
- G. Permanent Pavements and Parking Facilities:
  - 1. Prior to Substantial Completion, bases for permanent roads and parking areas may be used for construction traffic.
  - 2. Avoid traffic loading beyond paving design capacity. Tracked vehicles not allowed.
  - 3. Use of permanent parking structures is not permitted.

- H. Maintenance:
  - 1. Maintain traffic and parking areas in sound condition free of excavated material, construction equipment, products, mud, etc.
  - 2. Maintain paved areas used for construction; promptly repair breaks, potholes, low areas, standing water and other deficiencies, to maintain paving and drainage in original or specified condition.
- I. Removal and Repair:
  - 1. Remove temporary materials and construction at Substantial Completion.
  - 2. Remove underground work and compacted materials to depth of 600 mm; fill and grade site as specified.
  - 3. Repair existing and permanent facilities damaged by use, to original and specified condition respectively.

#### 1.29 PROGRESS CLEANING AND WASTE REMOVAL

- A. Maintain areas free of waste materials, debris and rubbish; periodically collect, remove and dispose them off-site. Maintain site in clean and orderly condition.
- B. Remove debris and rubbish from pipe chases, plenums, attics, crawl spaces and other closed or remote spaces, prior to enclosing spaces.
- C. Broom and vacuum clean interior areas prior to start of surface finishing, and continue cleaning to eliminate dust.
- D. Open free-fall chutes are not permitted. Terminate closed chutes into appropriate containers with lids.

#### 1.30 PROJECT IDENTIFICATION

- A. Project Identification Sign:
  - 1. Painted sign of construction, design and location as shown on the Drawings or as directed by the Engineer.
  - 2. Unless otherwise indicated on drawings or directed by the Engineer, the content of the Project Identification Sign shall include the following:
    - a. Project number and title, logo and name of Employer as indicated on Contract Documents.
    - b. Names and titles of authorities.
    - c. Names and titles of Engineer and Supervision Consultants.
    - d. Name of Prime Contractor and major Sub-Contractors.
- B. Project Informational Signs: Of same colors and lettering as Project Identification Sign, or standard products; size lettering for legibility at 30 m distance.
  - 1. Provide sign at each field office, storage shed and directional signs to direct traffic into and within site. Relocate as Work progress requires.
  - 2. Provide local relevant authorities' directional traffic signs to and within site.
  - 3. No other signs are allowed without Employer permission, except those required by law.
- C. Design sign and structure to withstand 160 km/hr wind velocity.
- D. Sign Painter: Experienced as professional sign painter for minimum five years.

- E. Finishes and Painting: Adequate to withstand weathering, fading and chipping for duration of construction.
- F. Submit for Engineer's approval, shop drawings showing content, layout, lettering, color, foundation, structure and all sizes and dimensions.
- G. Sign Materials: Unless otherwise indicated on drawings, or directed by the Engineer:
  - 1. Structure and Framing: Wood or metal, structurally adequate.
  - 2. Sign Surfaces: Exterior grade plywood with medium density overlay, minimum 19 mm thick, standard large sizes to minimize joints.
  - 3. Rough Hardware: Galvanized.
  - 4. Paint and Primers: Exterior quality, two coats; sign background of color as selected by the Engineer.
  - 5. Lettering: Exterior quality paint, colors as selected by the Engineer.
- H. Installation:
  - 1. Install project identification sign at designated location within 14 days after Contract implementation commencement date.
  - 2. Erect supports and framing on secure foundation, rigidly braced and framed to resist wind loadings.
  - 3. Install sign surface plumb and level, with butt joints. Anchor securely.
  - 4. Paint exposed surfaces of sign, supports and framing.
- I. Maintenance: Maintain signs and supports clean, repair deterioration and damage.
- J. Removal: Remove signs, framing, supports and foundations at completion of Project and restore area.

### 1.31 FIELD OFFICES AND SHEDS

- A. Scope:
  - 1. This section specifies the temporary field offices and sheds, services and facilities required in the construction, completion and maintenance of works.
  - 2. Any proposed change in location or relocation of offices must be preceded by submission for Engineer's approval of a drawing, indicating such change.
- B. Offices: Weather tight, with lighting, electrical outlets, heating, cooling and ventilating equipment, and equipped with sturdy furniture, drawing rack and drawing display table.
- C. Provide separate private offices with security fencing around the perimeter, similarly equipped and furnished, for use of the Engineer.
- D. Offices shall include the main structure, sheltered car park, temporary water tanks and temporary sewage collection and treatment systems.
- E. Locate offices and sheds at minimum required distance from structures.
- F. Prepare and submit for Engineer's approval an architectural layout plan of site offices.
- G. Do not use permanent or existing facilities for field offices or for storage unless otherwise agreed with Employer.

- H. Construction: Portable or mobile buildings, or buildings constructed with floors raised above ground, securely fixed to foundations with steps & landings at entrance.
1. Construction: Structurally sound, secure and weathertight enclosures. Maintain during progress of Work; remove at completion of Work.
  2. Temperature Transmission Resistance of Floors, Walls and Ceilings: Compatible with occupancy and storage requirements.
  3. Exterior Materials: Weather resistant; color as selected by the Engineer.
  4. Interior Materials in Offices: Sheet type materials for walls and ceilings, pre-finished or painted; resilient floors and bases.
  5. Lighting for Offices: 538 lx at desktop height, exterior lighting at each entrance door.
  6. Fire Extinguishers: Appropriate type fire extinguisher at each office and each storage area.
  7. Interior Materials in Storage Sheds: As required to provide specified conditions for storage of products.
- I. Environmental Control:
1. Heating, Cooling and Ventilating for Offices: Heat pump split unit systems to maintain 20°C heating and 23°C cooling.
  2. Storage Spaces: Heating and ventilation as needed to maintain products in accordance with Contract Documents; and lighting for maintenance and inspection of products.
- J. Contractor's Site Office Schedule:
1. The site area is limited. The Contractor shall make arrangement to provide and maintain throughout the period of construction in a convenient location approved by the Engineer, adequate heated and air conditioned office accommodation for the Contractor's use and the use of his Sub-Contractors. Such accommodation shall include proper messing and sanitary facilities and shall be provided with suitable fire fighting facilities and adequate means of escape in case of fire, all to the approval of the Engineer.
  2. The Contractor shall not allow any of his employees or those of his Sub-Contractors to maintain any temporary or permanent living quarters within the construction site.
- K. Engineer's and Employer's Site Offices Accommodation and Equipment Schedule: The Contractor shall erect, equip, furnish, maintain, service and ensure for the entire construction period until at least the issue of the Taking Over Certificate, or such time as the Engineer may direct, the Engineer's and Employer Site Offices with the following characteristics, tools, instruments, fire means, equipment and furniture, all to the satisfaction of the Engineer:
1. Site Offices: **One** prefabricated portable or demountable offices or other as may be approved by the Engineer, **size 3m x 9m**, for the sole use of the Engineer's Representative and his staff, comprising:
    - a. 1 office room.
    - b. 1 meeting room.
    - c. 1 kitchenette and 1 toilet.
    - d. 1 store room.
  2. Site Office and Meeting Room Furniture and Equipment:
    - a. Office Room:
      - 1) 2 desks with lockable drawers and swivel chairs.

- 2) 2 lockable steel filing cabinets.
  - 3) 4 office chairs.
  - 4) 1 drawing hanger for 10 sets.
  - 5) 2 shelves.
  - 6) 2 pin boards.
  - 7) 2 waste paper baskets.
  - 8) 1 reference table.
  - 9) 2 computers (as defined hereinafter).
  - b. Kitchenette:
    - 1) 1 table for 6 people.
    - 2) 6 polypropylene chairs.
    - 3) 1 refrigerator 14 cu. ft. capacity.
    - 4) 1 coffee machine.
    - 5) 1 water filter and 20 liters water cooler/hot/cold.
    - 6) 2 electric boiling rings.
    - 7) 1 microwave.
    - 8) 1 stainless steel sink and drainer.
    - 9) 1 heat resistant worktop.
    - 10) 1 set of storage cupboards.
    - 11) 1 set of crockery and cutlery for each member of the staff.
    - 12) 1 large wastebasket with cover.
    - 13) All necessary consumables throughout the Contract duration.
  - c. Toilet:
    - 1) 1 w.c. suite.
    - 2) 1 hose bib.
    - 3) 1 toilet roll holder.
    - 4) 1 wash hand basin.
    - 5) 1 mirror with shelf.
    - 6) 1 soap dispenser.
    - 7) 1 automatic electric hand dryer or 1 paper towel holder.
    - 8) 1 wastebasket with cover.
    - 9) All necessary consumables throughout the Contract duration.
  - d. Meeting Room:
    - 1) 1 conference table for 15 people.
    - 2) 15 chairs.
    - 3) 2 pin boards.
    - 4) 2 shelves.
    - 5) 2 waste baskets.
    - 6) 1 reference table.
    - 7) 1 projector with projection screen.
    - 8) 1 computer (as defined hereinafter).
  - e. Store Room:
    - 1) Shelving units.
    - 2) Drawing hangers and racks.
    - 3) 1 reference table.
3. Site Offices and Meeting Room Services: The Contractor shall provide and maintain throughout the whole Contract duration, the following minimum services:
- a. Heating and air-conditioning.
  - b. Electric power supply and lighting installations.
  - c. Water supply.

- d. Drainage system.
- e. Portable firefighting extinguishers.
- f. Cleaning facilities and general attendance with necessary personnel.
- g. One HP Ink Jet colored printer with A4 & A3 papers.
- h. One HP Laser Jet printer with A4 papers.
- i. One digital camera (Canon, minimum 14 mega pixels with 32 GB memory stick & USB cable).
- j. One multifunction colored photocopying machines (digital copier, network printer & network color scanner), size A3 & A4, including all consumables and photocopying papers throughout the Contract duration.
- k. One plain paper modern fax machine including all consumables throughout the Contract duration.
- l. Telephone Service: Two telephone lines (one mobile cellular line and one fixed telephone line) with machine devices, including cost of installation, maintenance and all rental and local call charges.
- m. Facsimile Service: One fixed telephone line shall be dedicated to facsimile machine and shall include direct dialing facility.
- n. Computer System:
  - 1) Three computers, each equipped with the latest Processor Intel, minimum 3.2 GHz, 2.0 GB of Ram, and 150 GB hard disk capacity; video local bus; 256 MB VGA; 56x CD drive (Read/Write); 16x DVD drive (Read/Write); internet and e-mail service modem; English-Arabic keyboard; SVGA Flat, non-interlaced, low power, low radiation 19 inch rotating colored LED monitor; necessary ports; optical mouse; and antistatic dust covers.
  - 2) One latest laptop.
  - 3) Software: License for latest version of the following:
    - a) Windows and Microsoft Office latest edition.
    - b) AutoCAD latest edition (3 standalone).
    - c) Primavera latest edition (3 standalone).
    - d) Adobe Acrobat Reader/Writer Pro latest edition.
  - 4) Internet Connection: Minimum speed 4 mbps.
  - 5) Uninterruptible power supply (UPS) for all above equipment with minimum one-hour backup batteries.
  - 6) Computer table and chair;
  - 7) Network installation including all necessary cabling, rack, switches and wireless router to connect all computers, printers, copier and UPS.
  - 8) All consumables with all stationery and offices supplies throughout the Contract duration.
  - 9) Maintenance for all equipment throughout Contract duration.
- o. At the end of the project, all the above equipment shall remain the property of the Contractor.

- L. Storage Areas and Sheds: The Contractor shall provide on-site weatherproof sheds and storage facilities for the materials intended for the Works. The Contractor shall maintain and remove the same on completion of the Works.
  - 1. Size to storage requirements for products of individual specification sections, allowing for access, and orderly provision for maintenance and for inspection of products.
- M. Preparation:
  - 1. Fill and grade sites for temporary structures, facilities and controls.
  - 2. Slope for drainage away from site offices.
- N. Installation: Install office spaces ready for occupancy 14 days after Contract implementation commencement date.
  - 1. Parking: Six hard surfaced covered parking spaces for use by Engineer, connected to office by hard surfaced walk.
  - 2. Employee Residential Occupancy: Not allowed on Employer's property.
- O. Maintenance, Cleaning and Attendance upon Offices Accommodation:
  - 1. Provide daily cleaning and maintenance for offices and storage areas.
  - 2. Provide full time attendance of the Engineer's site office accommodation including one cleaner, one tea boy and one messenger. All to attend upon the requirements of the staff. The cost of cleaning materials and consumable such as, paper towels, paper tissues, toilet rolls, cookery and cutlery, tea, coffee, sugar, etc. shall be paid for by the Contractor. The services of the tea boy and messenger, the provision of consumables and cleaning materials and the maintenance of the site office shall be extended to cover the construction duration until completion. Consumables shall be supplied and delivered to the site at regular intervals as directed by the Engineer.
  - 3. Maintain approach walks free of mud, dust, water, etc.

### 1.32 VEHICLES

- A. Not Applicable.

### 1.33 VEHICULAR ACCESS

- A. Construct temporary access roads from public thoroughfares to serve construction area, of width and load bearing capacity to accommodate unimpeded traffic for construction purposes.
- B. Construct temporary ditches and culverts to allow unimpeded drainage.
- C. Extend and relocate vehicular access as Work progress requires, provide detours as necessary for unimpeded traffic flow.
- D. Locate as indicated on Drawings, or where directed by the Engineer.
- E. Provide unimpeded access for emergency vehicles. Maintain 6 m wide driveways with turning space between and around combustible materials.
- F. Provide and maintain access to fire hydrants and control valves free of obstructions.

- G. Unless otherwise directed by the Engineer, do not use existing on-site roads for construction traffic.

#### 1.34 PLANT AND SMALL TOOLS

- A. The Contractor shall provide all constructional plant and small tools necessary for the proper execution of the Works.

#### 1.35 SCAFFOLDING AND HOISTING

- A. The Contractor shall provide, erect and maintain proper and adequate scaffolding, staging, stairs, ladders, chutes, materials hoist, special rigging and the like required for the Work and shall comply with all requests, safety instructions, etc., issued by the Engineer relating thereto. The Contractor shall provide all necessary guards, signals, safety devices and the like required for safety of operations including suitable runways from the hoists to each level and roof.
- B. The Contractor shall also provide, erect and maintain personnel hoist adequate to transport all personnel of Employer, Engineer/Supervision Consultant and Contractor.
- C. Material hoists shall not be used for transporting personnel and only skilled personnel shall be used for the operation and maintenance of hoists. The construction, maintenance and operation of hoists shall conform to the applicable requirements of the applicable Codes in force. Use of permanent lifts equipment (if any) for transporting materials or personnel will not be allowed except with prior written permission of the Engineer.
- D. Location and means of operation of hoist shall be subject to the Engineer's approval and shall in no way hinder the progress of the work and shall not relieve the Contractor from his duties and obligations under the Contract.
- E. Scaffolding shall be of tubular steel construction and designed in accordance with the requirements of BS 5973 and BS 5974.
- F. Hoists, chute, scaffolding and the like shall be so constructed as to prevent damage, staining or marring of the Permanent Work. No materials, rubbish or debris shall be permitted to drop free, but shall be removed by use of hoists or fully enclosed rubbish chutes.
- G. Provide suitable safety railings for stairs, ladders, ramps, etc.
- H. On completion of the Work, clear away and remove all scaffolding and hoisting.

#### 1.36 REMOVAL OF UTILITIES, FACILITIES AND CONTROLS

- A. At the end of the entire project, remove temporary utilities, materials, equipment, facilities and controls.
  - 1. Remove offices with foundations, utility services and debris.
  - 2. Remove underground installations to minimum depth of 600 mm, unless otherwise indicated on Drawings.
  - 3. Restore areas and make good all disturbed surfaces.

4. Restore existing facilities used during construction to original condition.  
Restore permanent facilities used during construction to specified condition.
5. Clean and repair damage caused by installation or use of temporary work.

#### PART 2 PRODUCTS

Not Applicable.

#### PART 3 EXECUTION

Not Applicable.

END OF SECTION

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SECTION 01600  
PRODUCT REQUIREMENTS

PART 1 GENERAL

1.1 SCOPE

- A. This section specifies the General Requirements for:
  - 1. Products.
  - 2. Product delivery requirements.
  - 3. Product storage and handling requirements.
  - 4. Product options.
  - 5. Product substitution procedures.
  - 6. Protection.
  - 7. Equipment electrical characteristics and components.
- B. The requirements of this section are augmented by specific clauses specifying quality throughout all sections of the Specification.

1.2 PERFORMANCE AND STANDARDS

- A. Neither asbestos containing materials (ACM) nor chromate copper arsenate (CCA) treated timber shall be used in the project.
- B. All products shall perform as specified and the handling, transportation and storage thereof shall be as specified and such that the ultimate performance of the products shall in no way be impaired.
- C. The quality of products and reference to Standards and Codes of Practice is covered in the "Administrative Requirements" Section.
- D. Where, in the course of the Project, materials, products, assemblies, equipment or techniques, are required which are not named, definitively described or implied in the Specification, they shall nonetheless conform to all relevant both as regards Materials and Workmanship and quality, suitability and performance which are not less than implicit in this Specification to the satisfaction of the Engineer.
- E. The Contractor shall at all time use his best endeavors to produce materials and work of a consistent and high quality and standard, whether or not such standard is identifiable in the Specification.
- F. The Contractor shall abide by the Engineer's interpretation of the Specification and shall comply with his decisions regarding the quality of Materials and Workmanship.

1.3 RELATED ITEMS

- A. General Requirements: Administrative regulatory requirements, submittal procedures, and execution requirements for warranties and bonds.

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#### 1.4 SUBMITTALS

- A. General Requirements: Submittal procedures.

#### 1.5 PRODUCTS

- A. Furnish products of qualified manufacturers suitable for intended use. Furnish products of each type by single manufacturer unless specified otherwise.
- B. Country of Manufacturer's origin shall be approved by the Engineer.
- C. Do not use materials and equipment removed from existing premises, except as specifically permitted by Contract Documents.
- D. Furnish interchangeable components from same manufacturer for components being replaced.

#### 1.6 PRODUCT DELIVERY REQUIREMENTS

- A. Transport and handle products in accordance with manufacturer's instructions.
- B. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct and products are undamaged.
- C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

#### 1.7 PRODUCT STORAGE AND HANDLING REQUIREMENTS

- A. Store and protect products in accordance with manufacturers' instructions.
- B. Store with seals and labels intact and legible.
- C. Store sensitive products in weather tight, climate controlled, enclosures in an environment favorable to product.
- D. For exterior storage of fabricated products, place on sloped supports above ground.
- E. Provide off-site storage and protection when site does not permit on-site storage or protection.
- F. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to prevent condensation and degradation of products.
- G. Store loose granular materials on solid flat surfaces in well-drained area. Prevent mixing with foreign matter.
- H. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.
- I. Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

## 1.8 PRODUCT OPTIONS

- A. Products Specified by Reference Standards or by Description Only: Any product meeting those standards, equivalent standards, or description.
- B. Products Specified by Naming One or More Manufacturers: Products of one of manufacturers named and meeting specifications, no options or substitutions allowed.
- C. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions: Submit request for substitution for any manufacturer not named in accordance with the following article.

## 1.9 PRODUCT SUBSTITUTION PROCEDURES

- A. The Engineer will consider requests for Substitutions only within 30 days after Contract implementation commencement date.
- B. Substitutions may be considered when a product becomes unavailable through no fault of Contractor.
- C. Document each request with complete data substantiating compliance of proposed Substitution with Contract Documents.
- D. A request constitutes a representation that Contractor:
  - 1. Has investigated proposed product and determined that it meets or exceeds quality level of specified product.
  - 2. Will provide same warranty for Substitution as for specified product.
  - 3. Will coordinate installation and make changes to other Work which may be required for the Work to be complete with no additional cost to Employer.
  - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
  - 5. Will reimburse Employer and Engineer for review or redesign services associated with re-approval by authorities having jurisdiction.
- E. Substitutions will not be considered when they are indicated or implied on Shop Drawing or Product Data submittals, without separate written request, or when acceptance will require revision to Contract Documents.
- F. Substitution Submittal Procedure:
  - 1. Submit three copies of request for Substitution for consideration. Limit each request to one proposed Substitution.
  - 2. Submit Shop Drawings, Product Data, and certified test results attesting to proposed product equivalence. Burden of proof is on proposer.
  - 3. Engineer will notify Contractor in writing of decision to accept or reject request.

## 1.10 PROTECTION

- A. The Contractor shall provide and maintain until practical completion all necessary protection to be installed to the work and equipment to prevent damage or deterioration.

## PART 2 PRODUCTS

### 2.1 EQUIPMENT ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. Wiring Terminations: Furnish terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Include lugs for terminal box.
- B. Cord and Plug: Furnish minimum 2 m cord and plug including grounding connector for connection to electric wiring system. Cord of longer length is specified in individual specification sections.

## PART 3 EXECUTION

Not Applicable.

END OF SECTION

## SECTION 01700

### EXECUTION REQUIREMENTS

#### PART 1 GENERAL

##### 1.1 SECTION INCLUDES

- A. Closeout procedures.
- B. Cleaning.
- C. Starting of systems.
- D. Demonstration and instructions.
- E. Testing, adjusting and balancing.
- F. Protecting installed construction.
- G. Project record documents.
- H. Operation and maintenance data.
- I. Manual for materials and finishes.
- J. Manual for equipment and systems.
- K. Instruction of Employer personnel.
- L. Spare parts and maintenance products.
- M. Product warranties and product bonds.
- N. Maintenance service.
- O. Protection and making good.

##### 1.2 CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for Engineer's review.
- B. Provide submittals to the Engineer required by authorities having jurisdiction.
- C. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments and sum remaining due.
- D. Employer will occupy all or portions of the completed works as directed.

### 1.3 CLEANING

#### A. General:

1. Execute cleaning during progress of the work and at completion of the work.
2. If the Contractor fails to clean up during or at completion of work, the Employer may do so, and the cost thereof shall be charged to the Contractor.
3. Conduct cleaning and disposal operations to comply with codes, ordinances, and anti-pollution laws.
4. Use only those cleaning materials which will not create hazards to health or property and which will not damage surfaces.
5. Use only those cleaning materials and methods recommended by manufacturer of the surface material to be cleaned.

#### B. Cleaning during Construction:

1. Execute periodic cleaning to keep the work, the site and adjacent properties free from accumulations of waste material, rubbish and windblown debris, resulting from construction operations.
2. Provide on-site containers for the collection of waste materials, debris, etc.
3. Remove waste materials, debris and rubbish from the site periodically and dispose off at legal disposal areas away from the site.

#### C. Dust Control:

1. Clean interior spaces to the start of finish painting and continue cleaning on and as-needed basis until painting is finished.
2. Schedule operations so that dust and other contaminants resulting from cleaning process will not fall on wet or newly-coated surfaces.

#### D. Final Cleaning:

1. Employ skilled workmen or specialized firm for final cleaning.
2. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels and other foreign materials from sight-exposed interior and exterior surfaces.
3. Clean interior and exterior glass, and surfaces exposed to view; remove temporary labels, stains and foreign substances, wash and shine glazing, and polish transparent and glossy surfaces.
4. Wax and polish finish floors.
5. Clean all hardware with cleaning materials appropriate to surface and material being cleaned.
6. Clean equipment and fixtures to sanitary condition with cleaning materials appropriate to surface and material being cleaned.
7. Ventilating System: Replace filters of operating equipment; clean ducts, blowers and coils if units were operated without filters during construction.
8. Clean debris from roofs, gutters, downspouts, and drainage systems.
9. Clean site; sweep paved areas, rake clean landscaped surfaces.
10. Comply with all special cleaning instructions contained in the specifications.
11. Remove temporary services, construction equipment, tools and construction facilities, mock-ups, temporary structures, surplus materials, debris, waste, and rubbish from site.
12. Put site in neat, orderly condition, ready for use. Leave all spaces clean and free from debris.
13. Prior to final completion, conduct an inspection of sight-exposed interior and exterior surfaces, and all work areas, to verify that the entire work is clean.

#### 1.4 STARTING OF SYSTEMS

- A. Coordinate schedule for start-up of various equipment and systems.
- B. Notify the Engineer seven days prior to start-up of each item, unless otherwise specified in individual specification sections.
- C. Verify each piece of equipment/system has been checked for proper lubrication, drive rotation, belt tension, control sequence and for conditions which may cause damage.
- D. Verify tests, meter readings and specified electrical characteristics agree with those required by equipment or system manufacturer.
- E. Verify that wiring and support components for equipment are complete and tested.
- F. Execute start-up under supervision of applicable manufacturer's representative and Contractors' personnel in accordance with manufacturers' instructions.
- G. When specified in individual specification sections, require manufacturer to provide authorized representative to be present at site to inspect, check and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.
- H. Submit a written report as specified in the "Submittal Procedures" Section of the General Requirements, that equipment or system has been properly installed and is functioning correctly.

#### 1.5 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate operation and maintenance of products to Employer's personnel two weeks prior to date of substantial completion and/or final inspection.
- B. Demonstrate Project equipment and instruct in a classroom environment located at site and instructed by qualified applicable personnel or manufacturer's representative who is knowledgeable about the Project.
- C. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.
- D. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Employer's personnel in detail to explain all aspects of operation and maintenance.
- E. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at agreed time and at equipment location.
- F. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.
- G. Required instruction time for each item of equipment and system is specified in individual sections.

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## 1.6 TESTING, ADJUSTING AND BALANCING

- A. Contractor will appoint, employ and pay for services of an independent firm approved by the Engineer, to perform testing, adjusting and balancing.
- B. The independent firm will perform services stated in the Specifications
- C. Reports will be submitted by the independent firm to the Engineer indicating observations and results of tests and indicating compliance or non-compliance with requirements of Contract Documents.

## 1.7 PROTECTING INSTALLED CONSTRUCTION

- A. Protect installed Work and provide special protection where specified in individual specification sections.
- B. Provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.
- C. Provide protective coverings at walls, projections, jambs, sills and soffit of openings.
- D. Protect floors, stairs and other surfaces from traffic, dirt, wear, damage, or movement of heavy objects by protecting with durable sheet materials.
- E. Prohibit traffic or storage upon waterproofed or roofed surfaces. When traffic or activity is necessary, obtain recommendations for protection from waterproofing or roofing material manufacturer.
- F. Prohibit traffic from landscaped areas.

## 1.8 PROJECT RECORD DOCUMENTS

- A. Maintain on site one set of the following record documents; record actual revisions to the Work:
  - 1. Drawings.
  - 2. Specifications.
  - 3. Addenda.
  - 4. Change Orders and other modifications to the Contract.
  - 5. Reviewed Shop Drawings, Product Data and Samples.
  - 6. Manufacturer's instruction for assembly, installation and adjusting.
- B. Ensure entries are complete and accurate enabling future reference by Employer.
- C. Store record documents separate from documents used for construction.
- D. Record information concurrent with construction progress, not less than weekly.
- E. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:
  - 1. Manufacturer's name and product model and number.
  - 2. Product substitutions or alternates utilized.
  - 3. Changes made by Addenda and modifications.

- F. Record Drawings and Shop Drawings: Legibly mark each item to record actual construction including:
1. Measured depths of foundations in relation to finish floor datum.
  2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
  3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.
  4. Field changes of dimension and detail.
  5. Details not on original Contract drawings.
- G. Submit documents to the Engineer with claim for final Application for Payment.

#### 1.9 OPERATION AND MAINTENANCE DATA

- A. Format:
1. Prepare instructions and data by personnel experienced in maintenance and operation of described projects.
  2. Prepare data in the form of an instructional manual.
  3. Submit data bound in A4 text pages.
  4. Binders: Commercial quality binders with durable plastic covers. When multiple binders are used, correlate data into related consistent groupings.
  5. Cover: Identify each binder with printed title "Operation and Maintenance Instructions", title of project and subject matter of binder when multiple binders are required.
  6. Internally subdivide binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
  7. Drawings: Provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages.
  8. Contents: Prepare Table of Contents for each volume, with each product or system description identified, typed on white paper, in three parts as follows:
    - a. Part 1: Directory, listing names, addresses and telephone numbers of Engineer, Contractor, Subcontractors and major equipment suppliers.
    - b. Part 2: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses and telephone numbers of Subcontractors and suppliers. Identify the following:
      - 1) Significant design criteria.
      - 2) List of equipment.
      - 3) Parts list for each component.
      - 4) Operating instructions.
      - 5) Maintenance instructions for equipment and systems.
      - 6) Maintenance instructions for special finishes including recommended cleaning methods and materials, and special precautions identifying detrimental agents.
    - c. Part 3: Project documents and certificates, including the following:
      - 1) Shop drawings and product data.
      - 2) Air and water balance reports.
      - 3) Certificates.
      - 4) Photocopies of warranties
      - 5) Originals of bonds.

- B. Contents, Each Volume:
1. Table of Contents: Provide title of Project; names, addresses and telephone numbers of Engineer and Contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.
  2. For each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.
  3. Product Data: Mark each sheet to clearly identify specific products and components parts, and data applicable to installation. Delete inapplicable information.
  4. Drawings: Supplement product data to illustrate relations of components parts of equipment and systems, to show control and flow diagrams.
  5. Typed Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified in the "Quality Requirements" Section of the General Requirements.
  6. Warranties: Bind in copy of each.
  7. Bonds: Bind in original of each.

#### 1.10 MANUAL FOR MATERIALS AND FINISHES

- A. Submit four copies of preliminary draft or proposed formats and outlines of contents before start of Work. The Engineer will review draft and return one copy with comments.
- B. For equipment, or component parts of equipment put into service during construction and operated by Employer, submit documents within ten days after acceptance.
- C. Submit one copy of completed volumes 14 days prior to final inspection. Draft copy will be reviewed and returned after final inspection, with the Engineer's comments. Revise content of document sets as required prior to final submission.
- D. Submit four sets of revised final volumes in final form within 10 days after final inspection.
- E. Products, Applied Materials and Finishes: Include product data, with catalog number, size, composition, and color and texture designations. Include information for re-ordering custom manufactured products.
- F. Instructions for Care and Maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- G. Moisture Protection and Weather Exposed Products: Include product data listing applicable reference standards, chemical composition and details of installation. Include recommendations for inspections, maintenance and repair.
- H. Additional Requirements: As specified in individual product specification sections.
- I. Include listing in Table of Contents for design data, with tabbed fly sheet and space for insertion of data.

## 1.11 MANUAL FOR EQUIPMENT AND SYSTEMS

- A. Submit four copies of preliminary draft or proposed formats and outlines of contents before start of Work. The Engineer will review draft and return one copy with comments.
- B. For equipment, or component parts of equipment put into service during construction and operated by Employer, submit documents within ten days after acceptance.
- C. Submit one copy of completed volumes 15 days prior to final inspection. Draft copy will be reviewed and returned after final inspection, with the Engineer's comments. Revise content of document sets as required prior to final submission.
- D. Submit four sets of revised final volumes in final form within 10 days after final inspection.
- E. Each Item of Equipment and Each System: Include description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and model number of replaceable parts.
- F. Panelboard Circuit Directories: Provide electrical service characteristics, controls, and communications.
- G. Include color coded wiring diagrams as installed.
- H. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shut-down, and emergency instructions. Include summer, winter, and special operating instructions.
- I. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
- J. Include servicing and lubrication schedule, and list of lubricants required.
- K. Include manufacturer's printed operation and maintenance instructions.
- L. Include sequence of operation by controls manufacturer.
- M. Include original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
- N. Include control diagrams by controls manufacturer as installed.
- O. Include Contractor's coordination drawings, with color coded piping diagrams as installed.
- P. Include charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.

- Q. Include list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.
- R. Include test and balancing reports as specified in the "Quality Requirements" Section of the General Requirements.
- S. Additional Requirements: As specified in individual product specification sections.
- T. Include listing in Table of Contents for design data, with tabbed dividers and space for insertion of data.

#### 1.12 INSTRUCTION OF EMPLOYER PERSONNEL

- A. Before final inspection, instruct Employer's designated personnel in operation, adjustment, and maintenance of products, equipment, and systems, at agreed upon times.
- B. For equipment requiring seasonal operation, perform instructions for other seasons within six months.
- C. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
- D. Prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instructions.

#### 1.13 SPARE PARTS AND MAINTENANCE PRODUCTS

- A. Furnish spare parts, maintenance and extra products in quantities specified in individual specification sections.
- B. Deliver to Project site and place in location as directed by Employer; obtain receipt prior to final payment.

#### 1.14 PRODUCT WARRANTIES AND PRODUCT BONDS

- A. Obtain warranties and bonds executed in duplicate by responsible subcontractors, suppliers and manufacturers, within ten days after completion of applicable item of work.
- B. Execute and assemble transferable warranty documents and bonds from subcontractors, suppliers, and manufacturers.
- C. Verify documents are in proper form, contain full information and are notarized.
- D. Co-execute submittals when required.
- E. Include Table of Contents and assemble in binder with durable plastic cover.
- F. Submit prior to final Application for Payment.

- G. Time of Submittals:
1. For equipment or component parts of equipment put into service during construction with Employer's permission, submit documents within ten days after acceptance.
  2. Make other submittals within ten days after Date of Substantial Completion, prior to final Application for Payment.
  3. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit within ten days after acceptance, listing date of acceptance as beginning of warranty or bond period.

#### 1.15 MAINTENANCE SERVICE

- A. Furnish service and maintenance of components indicated in specification sections.
- B. Examine system components at frequency consistent with reliable operation. Clean, adjust and lubricate as required.
- C. Include systematic examination, adjustment and lubrication of components. Repair or replace parts whenever required. Use parts produced by manufacturer of original component.
- D. Do not assign or transfer maintenance service to agent or Subcontractor without prior written consent of the Employer.

#### 1.16 PROTECTION AND MAKING GOOD

- A. The Contractor shall protect all completed Works from damage until the completion and handing over of the Works to the approval of the Engineer.
- B. Should any Works be damaged before handing over of the Works, the Contractor shall at his expense make good or replace as required, to the satisfaction of the Engineer.

### PART 2 PRODUCTS

Not Applicable.

### PART 3 EXECUTION

Not Applicable.

END OF SECTION

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## SECTION 02082

### MANHOLES AND STRUCTURES

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
1. Precast or cast-in-place reinforced concrete manholes and structures such as chambers, pumping stations, etc., with masonry transition to cover frame, covers, steps, anchorage and accessories.
  2. Manhole connections to existing lines.
- B. Related Sections:
1. Section 02085 - Valves and Valve Boxes.
  2. Section 02315 - Excavation.
  3. Section 02320 - Backfill.
  4. Section 02952 - Pipe and Manhole Testing.
  5. Section 03100 - Concrete Forms and Accessories.
  6. Section 03200 - Concrete Reinforcement.
  7. Section 03300 - Cast-in-Place Concrete.

##### 1.2 REFERENCES

- A. American Association of State Highway Transportation Officials:
1. AASHTO M288 - Geotextiles.
  2. AASHTO M306 - Drainage Structure Castings.
  3. AASHTO M91 - Sewer and Manhole Brick (Made from Clay or Shale).
- B. American Concrete Institute:
1. ACI 530/530.1 - Building Code Requirements for Masonry Structures and Specifications for Masonry Structures.
- C. ASTM International:
1. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
  2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  3. ASTM C32 - Standard Specification for Sewer and Manhole Brick (Solid Masonry Units Made From Clay or Shale).
  4. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
  5. ASTM C55 - Standard Specification for Concrete Brick.
  6. ASTM C478M - Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric).
  7. ASTM C497M - Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile (Metric).
  8. ASTM C913 - Standard Specification for Precast Concrete Water and Wastewater Structures.

9. ASTM C923M - Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric).

### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal.
- B. Shop Drawings: Indicate structure locations, elevations, piping, sizes and elevations of penetrations.
- C. Product Data: Submit manhole covers, component construction, features, configuration and dimensions.

### 1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with the drawings and to the satisfaction of the Engineer.
- B. 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 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Requirements for product storage and handling.
- B. Comply with precast concrete manufacturer's instructions and ASTM C913 for unloading, storing and moving precast manholes and drainage structures.
- C. Store precast concrete manholes and structures to prevent damage to Owner's property or other public or private property. Repair property damaged from materials storage.
- D. Mark each precast structure by indentation or waterproof paint showing date of manufacture, manufacturer, and identifying symbols and numbers shown on Drawings to indicate its intended use.

## PART 2 PRODUCTS

### 2.1 MANHOLES AND STRUCTURES

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

- B. Manhole and Structures Sections:
  - 1. Reinforced precast concrete in accordance with ASTM C478M with gaskets in accordance with ASTM C923M.
    - a. Joints for Precast Manholes and Structures: In accordance with ASTM C913; maximum leakage of 100 ml per hour per meter of joint at 100 cm of head.
  - 2. Reinforced cast-in-place concrete as specified in Section 03300.

## 2.2 FRAMES AND COVERS

- 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. Product Description:
  - 1. Heavy duty ductile iron covers and frames in accordance with BS EN 124 class D400.
  - 2. Medium duty ductile iron covers and frames in accordance with BS EN 124 class C250.
  - 3. Light duty ductile iron covers and frames in accordance with BS EN 124 class B125.

## 2.3 COMPONENTS

- A. Construction: Precast or cast-in-place reinforced concrete for structures components of type specified in Section 03300; sleeved to receive pipe sections; shaft type manhole for box culverts.
- B. Shape: Circular, square or rectangular.
- C. Clear Inside Dimensions: As indicated on Drawings.
- D. Design Depth: As indicated on Drawings.
- E. Clear Cover Opening: As indicated on Drawings.
- F. Pipe Entry: Furnish openings as required.
- G. Structure Joint Gaskets: ASTM C361/Rubber.
- H. Steps: Formed cast iron rungs; 20 mm diameter; Set into structure wall as indicated on Drawings.

## 2.4 ACCESSORIES

- A. Reinforcement: As specified in Section 03200.
- B. Bituminous Paint to External Surfaces in Contact with Soil: Fluid, cold applied, quick setting. Primer type shall be compatible with the bituminous paint.

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## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify items provided by other sections of Work are properly sized and located.
- C. Verify built-in items are in proper location, and ready for roughing into Work.
- D. Verify correct size of manhole and structure excavation.

### 3.2 PREPARATION

- A. Coordinate placement of box culvert, inlet and outlet pipe or duct sleeves required by other sections.
- B. Do not install manholes and structures where site conditions induce loads exceeding structural capacity of manholes or structures.
- C. Inspect precast concrete manholes and structures immediately prior to placement in excavation to verify manholes and structures are internally clean and free from damage. Remove and replace damaged units.

### 3.3 INSTALLATION - GENERAL

- A. Excavation and Backfill:
  - 1. Excavate for manholes and structures in accordance with Section 02315 in location and to depth shown. Provide 500 mm wide clearance around sidewalls of structures for construction operations.
  - 2. When groundwater is encountered, prevent accumulation of water in excavations. Place manholes or structures in dry trench.
  - 3. Where possibility exists of watertight structure becoming buoyant in flooded excavation, anchor structure to avoid flotation.
- B. Place foundation slab, trowel top surface level.
- C. Place precast concrete structure sections, plumb and level, trim to correct elevations, anchor to foundation slab.
- D. Cast-in-place concrete structures supported at proper grade and alignment as shown on Drawings.
- E. Backfill excavations for structures in accordance with Section 02320.
- F. Plumb and level to correct dimensions and elevations. As Work progresses, build fabricated metal items.
- G. Cut and fit for pipe and culvert.

- H. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as indicated on Drawings.
- I. 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.
- J. Set steps, and cover frames and covers to correct elevations, level without tipping.

#### 3.4 PRECAST CONCRETE MANHOLE AND STRUCTURES INSTALLATION

- A. Lift precast concrete structures at lifting points designated by manufacturer.
- B. When lowering structures into excavations and joining pipe to units, take precautions to ensure interior of box culvert or pipeline and structure remains clean.
- C. Set precast concrete structures bearing firmly and fully on crushed stone bedding compacted in accordance with provisions of Section 02320, or on plain concrete blinding cast-in-place as specified in Section 03300.
- D. Assemble multi-section structures by lowering each section into excavation. Install rubber gasket joints between precast sections in accordance with manufacturer's recommendations. Lower, set level and firmly position base section before placing additional sections.
- E. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.
- F. Joint sealing materials may be installed on site or at manufacturer's plant.
- G. Verify installed manholes and structures satisfy required alignment and grade.
- H. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe. Fill annular space with mortar.
- I. Cut pipe to finish flush with interior of structure.
- J. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as indicated on Drawings.

#### 3.5 CAST-IN-PLACE CONCRETE MANHOLE AND STRUCTURES INSTALLATION

- A. Cast-in-place plain concrete blinding to receive foundation slab as specified in Section 03300.
- B. Erect and brace forms against movement in accordance with Section 03100.
- C. Install reinforcing steel as indicated on Drawings and in accordance with Section 03200.
- D. Place and cure concrete in accordance with Section 03300.

### 3.6 MANHOLE CONNECTION TO EXISTING LINES

- A. Stake out location and burial depth of existing line in area of proposed manhole.
- B. Carefully excavate around existing line to adequate depth for foundation slab installation. Protect existing pipe from damage. Cut out soft spots and replace with granular fill compacted to 95% dry density.
- C. Cast-in-place plain concrete blinding to receive foundation slab as specified in Section 03300.
- D. Install precast concrete or cast-in-place concrete manhole around existing pipe in accordance with the appropriate paragraphs specified herein.
- E. Grout pipe entrances.
- F. Perform connection to existing pipe at approved time.
- G. Block upstream flow at existing manhole or structure with expandable plug.
- H. Use hydraulic saw to cut existing pipe at manhole entrance and exit and along pipe length at a point halfway up the outside diameter on each side of the pipe. Bottom half of pipe shall remain as manhole flow channel. Saw cut to have a smooth finish with top half of pipe flush with interior of manhole.
- I. Grout base of manhole to achieve slope to manhole channel. Trowel smooth.

### 3.7 SEWER MANHOLE DROP CONNECTIONS

- A. Construct drop connections into sewer manholes in accordance with the Drawings.
- B. Concrete encase pipe drop connection to minimum of 600 mm outside of manhole.
- C. Form channel from pipe drop to sweep into main channel as shown on drawings.

### 3.8 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Test cast-in-place concrete in accordance with Section 03300.
- C. Test concrete manhole and structure sections in accordance with ASTM C497M.

### 3.9 SCHEDULES

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

END OF SECTION

## SECTION 02085

### VALVES AND VALVE BOXES

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Valves.
  - 2. Valve boxes.
- B. Related Sections:
  - 1. Section 02082 - Manholes and Structures.
  - 2. Section 02315 - Excavation.
  - 3. Section 02320 - Backfill.
  - 4. Section 02324 - Trenching.
  - 5. Section 02952 - Pipe and Manhole Testing.
  - 6. Section 03300 - Cast-In-Place Concrete.

##### 1.2 REFERENCES

- A. American Water Works Association:
  - 1. AWWA C500 - Metal-Seated Gate Valves for Water Supply Service.
  - 2. AWWA C509 - Resilient-Seated Gate Valves for Water-Supply Service.
  - 3. AWWA C550 - Protecting Epoxy Interior Coating for Valves and Hydrants.
  - 4. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
- B. LIBNOR Standards.
- C. National Sanitation Foundation:
  - 1. NSF 61 - Drinking Water System Components - Health Effects.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Shop Drawing:
  - 1. Installation Plan: Submit description of proposed installation.
- C. Design Data: Submit manufacturer's latest published literature; include illustrations, installation instructions, maintenance instructions and parts lists.
- D. Manufacturer's Certificates: Submit Statement of Compliance, supporting data, from material suppliers attesting that valves and accessories provided meet or exceed AWWA Standards and specification requirements.

##### 1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.

- B. Project Record Documents: Record actual locations of valves.
- C. Provide Operation and Maintenance Data for valves.

#### 1.5 QUALITY ASSURANCE

- A. Perform Work as specified, in accordance with relevant local authorities' standards and regulations, 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.

#### 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. Prepare valves and accessories for shipment according to AWWA Standards and seal valve and ends to prevent entry of foreign matter into product body.
- C. Store products in areas protected from weather, moisture, or possible damage; do not store products directly on ground; handle products to prevent damage to interior or exterior surfaces.

#### 1.9 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements for environmental conditions affecting products on site.
- B. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

#### 1.10 COORDINATION

- A. General Requirements: Administrative requirements for coordination.
- B. Coordinate work with local relevant authorities and utilities within construction area.

## 1.11 MAINTENANCE MATERIALS

- A. General Requirements: Execution requirements for maintenance materials.
- B. Furnish one tee wrench to Owner; required length.

## 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 in accordance with local relevant authorities' standards, as specified, shown on the drawings and to the satisfaction of the Engineer.

### 2.2 VALVES

- A. As specified in individual specification section for each system.

### 2.3 VALVE BOXES AND CHAMBERS

- A. Reinforced Concrete Valve Boxes:
  - 1. Reinforced cast-in-place concrete as specified in Section 03300 or precast concrete to ASTM C478M with gaskets in accordance with ASTM C923M.
    - a. Joints for Precast Manholes and Structures: In accordance with ASTM C913; maximum leakage of 100 ml per hour per meter of joint at 100 cm of head.
  - 2. Reinforcement: As specified in Section 03200.
  - 3. Bituminous Paint to External Surfaces in Contact with Soil: Fluid, cold applied, quick setting. Primer type shall be compatible with bituminous paint.
- B. Ductile Iron Valve Boxes:
  - 1.  $\Phi$  300 mm Valves and Smaller: Domestic ductile iron, two-piece, screw type.
  - 2. Valves larger than  $\Phi$  300 mm: Domestic ductile iron, three-piece, screw type; round base.
  - 3. Cover: Ductile iron lid marked "Water Service Utility".
- C. Plastic Valve Boxes: Of approved type; as shown on drawings, to the satisfaction of the Engineer, and as per local relevant authorities' standards.

### 2.4 FRAMES AND COVERS

- A. Product Description:
  - 1. Heavy duty ductile iron covers and frames to BS EN 124 class D400.
  - 2. Medium duty ductile iron covers and frames to BS EN 124 class C250.
  - 3. Light duty ductile iron covers and frames to BS EN 124 class B125.

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## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Determine exact location and size of valves from Drawings; obtain clarification and directions from the Engineer prior to execution of work.
- C. Verify invert elevations prior to excavation and prior to installation of valves.

### 3.2 PREPARATION

- A. Identify required lines, levels, contours and datum locations.
- B. Locate, identify, and protect utilities to remain from damage.
- C. Do not interrupt existing utilities without permission and without making arrangements to provide temporary utility services.
  - 1. Notify the Engineer not less than two days in advance of proposed utility interruption.
  - 2. Do not proceed without written permission from the Engineer.
- D. Perform excavation, backfilling and compaction as per sections 02320 and 02324.

### 3.3 INSTALLATION

- A. Valves:
  - 1. Install valves in conjunction with pipe laying; set valves plumb.
  - 2. Provide buried valves with valve boxes installed flush with finished grade.
- B. Pressure Gages:
  - 1. Install pressure gages in piping tee with pressure gage valve located on pipe at most readable position.
  - 2. Install in the following locations and elsewhere as indicated:
    - a. At suction and discharge of each pump.
    - b. At discharge of each pressure reducing valve.
    - c. At building water service entrance.
    - d. At chilled water and condenser water inlets and outlets of chillers.
  - 3. Pressure Gage Needle Valves: Install in piping tee with snubber. Install siphon instead of snubber for steam pressure gages.
- C. Valve Boxes:
  - 1. Cast-In-Place Reinforced Concrete Valve Boxes:
    - a. Cast-in-place plain concrete blinding to receive foundation slab as specified in Section 03300.
    - b. Erect and brace forms against movement in accordance with Section 03100.
    - c. Install reinforcing steel as indicated on Drawings and in accordance with Section 03200.
    - d. Place and cure concrete in accordance with Section 03300.

2. Precast Reinforced Concrete Valve Boxes:
    - a. Lift precast concrete valve boxes at lifting points designated by manufacturer.
    - b. When lowering structures into excavations and joining pipe to units, take precautions to ensure interior of pipeline and structure remains clean.
    - c. Set precast concrete structures bearing firmly and fully on crushed stone bedding compacted in accordance with provisions of Section 02320, or on plain concrete blinding cast-in-place as specified in Section 03300.
    - d. Assemble multi-section structures by lowering each section into excavation. Install rubber gasket joints between precast sections in accordance with manufacturer's recommendations. Lower, set level and firmly position base section before placing additional sections.
    - e. Remove foreign materials from joint surfaces and verify sealing materials are placed properly. Maintain alignment between sections by using guide devices affixed to lower section.
    - f. Joint sealing materials may be installed on site or at manufacturer's plant.
    - g. Verify installed structures satisfy required alignment and grade.
    - h. Remove knockouts or cut structure to receive piping without creating openings larger than required to receive pipe. Fill annular space with mortar.
    - i. Cut pipe to finish flush with interior of structure.
    - j. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as indicated on Drawings.
  3. Ductile Iron Valve Boxes: As shown on the drawings, to the satisfaction of the Engineer, and as per local relevant authorities' standards.
  4. Plastic Valve Boxes: As shown on the drawings, to the satisfaction of the Engineer, and as per local relevant authorities' standards.
- D. Install Work in accordance with local relevant authorities' standards, as specified, shown on the drawings and to the satisfaction of the Engineer.

#### 3.4 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Perform pressure test on domestic site water distribution system as specified in section 02952 and in accordance with local relevant authorities' standards.

END OF SECTION

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## SECTION 02224

### DEMOLITION WORK

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Demolishing designated structures with foundations, existing items, etc.
  - 2. Removing designated items for reuse.
  - 3. Protecting items designated to remain.
  - 4. Removing demolished materials.

##### 1.2 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate demolition and removal sequences, location of items designated for reuse, and location and construction of temporary work.

##### 1.3 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Accurately record actual locations of capped utilities, concealed utilities discovered during demolition and subsurface obstructions.
- C. Operation and Maintenance Data: Submit description of system, inspection data and parts lists.

##### 1.4 QUALITY ASSURANCE

- A. Conform to applicable code for demolition work, dust control, and products requiring electrical disconnection and re-connection.
- B. Conform to applicable code for procedures when hazardous or contaminated materials are discovered.
- C. Obtain required permits from authorities having jurisdiction.
- D. Perform Work in accordance with the drawings and to the satisfaction of the Engineer.
- E. Maintain one copy of each document on site.

##### 1.5 PRE-INSTALLATION MEETINGS

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

## 1.6 SEQUENCING

- A. General Requirements: Requirements for sequencing.
- B. Sequence activities shall be as per approved methodology submitted to the Engineer for approval showing all necessary work orders and stages.
- C. Owner will conduct salvage operations before demolition begins to remove materials Owner chooses to retain.

## 1.7 SCHEDULING

- A. General Requirements: Requirements for scheduling.
- B. Schedule Work to precede and/or to coincide with new construction.
- C. Cooperate with Owner in scheduling noisy operations and waste removal that may impact other and/or Owners operation in adjoining spaces.
- D. Perform noisy, malodorous and dusty works between hours and on days approved by the Engineer.
- E. Coordinate utility and service interruptions with Owner.
  - 1. Minimize disruption to existing systems.

## 1.8 PROJECT CONDITIONS

- A. Conduct demolition to minimize interference with adjacent and occupied areas.
- B. Cease operations immediately if structure appears to be in danger and notify the Engineer. Do not resume operations until directed.

## PART 2 PRODUCTS

Not Applicable.

## PART 3 EXECUTION

### 3.1 PREPARATION

- A. Notify affected utility companies before starting work and comply with their requirements.
- B. Mark location and termination of utilities.
- C. Erect and maintain temporary barriers and security devices at approved locations, including warning signs and lights, and similar measures, for protection of the public, Owner and existing improvements indicated to remain.
- D. Erect and maintain weatherproof closures.

- E. Prevent spreading of dust, odors and noise.
- F. Provide appropriate temporary signage.

### 3.2 SALVAGE REQUIREMENTS

- A. Coordinate with Owner to identify all items to be removed and delivered to Owner.
- B. Tag items Owner designates for salvage.
- C. Protect designated salvage items from demolition operations until items are removed.
- D. Carefully remove items indicated to be salvaged.
- E. Disassemble as required to permit removal.
- F. Package small and loose parts to avoid loss.
- G. Mark packaged parts to permit identification and consolidation of each salvaged item.
- H. Prepare assembly instructions consistent with disassembled parts. Package assembly instructions in protective envelope and securely attach to each disassembled salvaged item.
- I. Deliver salvaged items to Owner. Obtain signed receipt from Owner.

### 3.3 DEMOLITION

- A. Conduct demolition to minimize interference with adjacent and occupied areas.
- B. Maintain protected egress from and access to adjacent areas at all times.
- C. Do not close or obstruct roadways and sidewalks without permits.
- D. Cease operations immediately when structure appears to be in danger and notify the Engineer.
- E. Disconnect and remove designated utilities within demolition areas.
- F. Cap and identify abandoned utilities at termination points when utility is not completely removed. Annotate Record Drawings indicating location and type of service for capped utilities remaining after demolition.
- G. Demolish in orderly and careful manner. Protect existing improvements, supporting members and the like.
- H. Carefully remove items indicated to be reused.
  - 1. Disassemble items as required to permit removal.
  - 2. Package small and loose parts to avoid loss.
  - 3. Mark items and packaged parts to permit reinstallation.
  - 4. Store items, protected from construction operations, until reinstalled.

- I. Remove demolished materials from site. Do not burn or bury materials on site.
- J. Remove materials as Work progresses. Upon completion of Work, leave areas in clean condition.
- K. Remove temporary Work.

#### 3.4 SCHEDULES

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

END OF SECTION

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## SECTION 02230

### SITE CLEARING

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Removing surface debris.
  - 2. Removing designated paving, curbs and the like.
  - 3. Removing designated trees, shrubs, and other plant life.
  - 4. Removing abandoned utilities.
  - 5. Clearing and Grubbing.
  - 6. Excavating topsoil.
  - 7. Compaction of surfaces.
- B. Related Sections:
  - 1. Section 02315 - Excavation.
  - 2. Section 02320 - Backfill.

##### 1.2 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data for herbicide. Indicate compliance with applicable codes for environmental protection.

##### 1.3 QUALITY ASSURANCE

- A. Perform Work in accordance with the drawings and to the satisfaction of the Engineer.
- B. Conform to applicable code for environmental requirements, disposal of debris, use of herbicides, etc.
- C. Maintain one copy of each document on site.

#### PART 2 PRODUCTS

##### 2.1 MATERIALS

- A. Herbicide: Type approved by authority having jurisdiction.

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## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify existing plant life designated to remain is tagged or identified.
- C. Identify salvage areas for placing removed materials designated to remain.

### 3.2 PREPARATION

- A. Notify all local authorities having jurisdiction not less than three working days before performing Work.
  - 1. Request underground utilities to be located and marked within and surrounding construction areas.

### 3.3 PROTECTION

- A. Locate, identify and protect utilities indicated to remain from damage.
- B. Protect trees, plant growth and features designated to remain as final landscaping.
- C. Protect bench marks, survey control points and existing structures designated to remain from damage or displacement.

### 3.4 CLEARING

- A. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Clearing shall also include the removal and disposal of structures that obstruct, encroach upon, or otherwise obstruct the work. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees designated to be left standing within the cleared areas shall be trimmed of dead branches 1½ inches (40 mm) or more in diameter and shall be trimmed of all branches the heights indicated or directed. Limbs and branches to be trimmed shall be neatly cut close to the bole of the tree or main branches. Cuts more than 1½ inches (40 mm) in diameter shall be painted with an approved tree-wound paint. Apply herbicide in accordance with the manufacturer's label to the top surface of stumps designated not to be removed.
- B. Clear areas required for access to site and execution of Work.
- C. Remove trees and shrubs. Remove stumps, main root ball, surface rock and the like.
- D. Clear undergrowth and deadwood, without disturbing subsoil.
- E. Apply herbicide to remaining stumps to inhibit growth.

### 3.5 GRUBBING

- A. Grubbing shall consist of the removal and disposal of stumps, roots larger than 75 mm 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, shall be removed to a depth of not less than 18 inches (455 mm) below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform to the original adjacent surface of the ground.

### 3.6 REMOVAL

- A. Remove debris, rock and extracted plant life from site.
- B. Remove paving, curbs and the like as indicated on Drawings. Neatly saw cut edges at right angle to surface.
- C. Remove abandoned utilities. Indicated removal termination point for underground utilities on Record Documents.
- D. Continuously clean-up and remove waste materials from site. Do not allow materials to accumulate on site.
- E. Do not burn or bury materials on site. Leave site in clean condition.

### 3.7 CLEANING

- A. Clean the site from debris and all surface material.
- B. Use air blower compressors for rocks substrates and where directed by the Engineer.

### 3.8 TOPSOIL EXCAVATION

- A. Excavate topsoil from entire site without mixing with foreign materials for use in finish grading down to natural ground level.
- B. Do not excavate wet topsoil.
- C. Compact surfaces to required density in areas that do not need further excavation; perform compaction in accordance with Section 02320.
- D. Remove topsoil from site and cart away to approved dumping areas.

### 3.9 SCHEDULES

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

END OF SECTION

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## SECTION 02315

### EXCAVATION

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes soil improvement and densification, general excavation in cut sections, structural excavation, excavation in unsuitable material encountered below foundation level, and manual excavation.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02320 - Backfill.

##### 1.2 REFERENCES

- A. ASTM International:
  - 1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m<sup>3</sup>).
  - 2. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
  - 3. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
  - 4. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- B. Local utility standards when working within 24 inches of utility lines.

##### 1.3 SUBMITTALS

- A. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.
- B. Shop Drawings: Indicate soil densification grid for each size and configuration footing requiring soils densification.

##### 1.4 QUALITY ASSURANCE

- A. Perform Work as shown on the drawings and to the satisfaction of the Engineer.
- B. Maintain one copy of each document on site.

##### 1.5 QUALIFICATIONS

- A. Prepare excavation protection plan under direct supervision of Professional Engineer experienced in design of this Work and approved by the Engineer.

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## PART 2 PRODUCTS

Not Applicable.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. Verify site conditions and note subsurface irregularities affecting Work of this section.

### 3.2 PREPARATION

- A. Request underground utilities (if any) to be located and marked within and surrounding construction areas not less than five working days before performing Work.
- B. Identify required lines, levels, contours and datum.
- C. Remove and relocate utilities.
- D. Protect utilities indicated to remain from damage.
- E. Protect plant life, lawns, rock outcroppings and other features remaining as portion of final landscaping.
- F. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, curbs, etc. from excavating equipment and vehicular traffic.

### 3.3 SOIL DENSIFICATION - VIBRO-COMPACTION (IF REQUIRED)

- A. Vibro-compact substrates below structure bearing surfaces as indicated on drawings before excavating site.
- B. Densify existing subsoils with relative density rating of compact to dense to attain relative density rating of very dense.
- C. Densification Equipment:
  - 1. Depth Vibrator: Poker type with follower tubes with visible marking every 300 mm to enable insertion depth measurement.
  - 2. Motion: Radial in horizontal plane.
  - 3. Data Acquisition System: Record amps or pressure of the vibrator motor over time and depth.
- D. Perform densification in presence of an approved Geotechnical Engineer directly under each footing with vibrator inserted in grid pattern at maximum 1.8 m on center.
  - 1. Arrange compaction grid for each structure for maximum number of insertion points and with outermost insertion points within the bearing area of footings.
  - 2. Adjust compaction grid arrangement and spacing as directed by the approved Geotechnical Engineer to achieve required densification.

- E. Insert vibrator to maximum specified depth. Densify soils for 30 seconds or other time as directed by the approved Geotechnical Engineer. Withdraw vibrator every 300 mm increments and repeat densification at each increment.
  - 1. When subsurface obstruction prevents vibrator insertion to specified depth, request instructions from the approved Geotechnical Engineer to compensate for obstruction.
- F. Tolerances:
  - 1. Maximum Deviation from Center of Completed Compaction: 200 mm from indicated position.
  - 2. Maximum Deviation from Vertical: 4 degrees during vibrator insertion.

### 3.4 EXCAVATION

- A. Underpin adjacent structures (if any) which may be damaged by excavation work.
- B. Excavate subsoil to accommodate foundations, base slabs, construction operations, etc.
- C. Coordinate excavation requirements with drawings and geotechnical report for working elevation to install foundations.
- D. Excavate to working elevation for foundations.
- E. Compact disturbed load bearing soil in direct contact with foundations to original bearing capacity; perform compaction in accordance with Section 02320.
- F. Compact surfaces under road construction to required density; perform compaction in accordance with Section 02320.
- G. Slope banks with machine to angle of repose or less until shored.
- H. Do not interfere with 45 degree bearing splay of foundations.
- I. Grade top perimeter of excavation to prevent surface water from draining therein.
- J. Trim excavation. Remove loose matter.
- K. Remove lumped subsoil, boulders and rocks up to 0.25 m<sup>3</sup> measured by volume, and remove larger solid mineral material with volume in excess of 0.25 m<sup>3</sup> as follow:
  - 1. Excavate and remove rock by an approved mechanical method. Drill holes and use wedges and mechanical disintegration compound to fracture rock.
  - 2. Cut away rock at bottom of excavation to form level bearing.
  - 3. Provide sound and unshattered base for foundations.
  - 4. Remove excavated materials from site to approved dumps.
- L. Notify the Engineer of unexpected subsurface conditions.
- M. Correct areas over excavated with lean concrete, cyclopean concrete and/or as directed by the Engineer at no additional cost.
- N. Remove excess and unsuitable materials from site to approved dumps outside the site.

- O. Stockpile selected excavated material intended for reuse in approved area on site in accordance with Section 02320; separate differing materials; protect from erosion.
- P. Repair or replace items indicated to remain damaged by excavation.

### 3.5 MANUAL EXCAVATION

- A. The Contractor shall perform all manual excavation and other work which is required to locate and to protect existing utilities or services within the limits of the Contract or at off-site locations in accordance with the requirements as specified herein and as directed by the Engineer.
- B. The existing utilities and services to be located and protected by manual excavation shall include, but not limited to, all sewer, water mains and lines, gas mains, oil lines, electric (both power and lighting), telephone, drainage and such others as may be encountered under this Contract or at off-set locations.
- C. The purpose of manual excavation is to determine the existence, location including depth, size, shape, composition and condition of all existing utilities and services and to protect them. The information obtained shall be recorded and shall be shown on working or shop drawings for the installation, relocation or protection of proposed or existing utilities or other underground installations such as, but not limited to, relocation of electrical distribution systems, waterline relocation, irrigation system, telephone systems, surface drainage lines, foundations, and other underground utility and roadway appurtenance covered under this Contract.
- D. The width of manually excavated trenches shall be such that a workman is able to excavate safely and efficiently to a depth determined as reasonable by the Engineer in consideration of the best existing utilities information available from local authorities.
- E. Manual excavations shall be carried out in the presence of the Engineer, taking all precautions to prevent damages to services, properties and persons, and any damage resulting from the negligence of the Contractor, his agents or his employees, shall be repaired at the Contractor's expense. This is in addition to any indemnities stipulated in the General Conditions of Contract and these Specifications dealing with Public Utilities and Safety Regulations.
- F. Before commencing manual excavation, the Contractor shall obtain approval of the relevant local authorities having jurisdiction and of the Engineer, and shall maintain records of such manual excavation as specified herein. The Contractor shall furnish two (2) copies to the Engineer of all the field notes and drawings with the details as recorded by the Contractor of all utilities and services located by manual excavation as specified herein and as directed by the Engineer.
- G. The Contractor shall provide all tools, labor, equipment and accessories as required to complete the manual excavation. Further, the Contractor shall provide, but not by way of limitation, all materials, labor and equipment necessary to protect the existing utilities, as well as any shoring, sheeting, dewatering and any other means required for protection during manual excavation.

- H. All materials removed shall be disposed off-site by the Contractor in accordance with this specifications section, unless the excavated materials are approved by the Engineer for use as backfill. All manually excavated trenches shall be backfilled, when backfilling is required as directed by the Engineer, with approved selected materials, placed and compacted, all in accordance with Section 02320. The Contractor shall place material, compact the same with care so as not to damage the existing utilities or services. The Contractor shall be responsible for any and all damages caused by his construction operation.
- I. No separate payment shall be made for manual excavation not approved by the Engineer.

### 3.6 FIELD QUALITY CONTROL

- A. Request visual inspection of bearing surfaces by an approved inspection firm before installing subsequent work.

### 3.7 PROTECTION

- A. Prevent displacement or loose soil from falling into excavation; maintain soil stability.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation.
- C. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earth operations.

END OF SECTION

## SECTION 02320

### BACKFILL

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. General filling and compaction in fill sections.
  - 2. Backfilling and compaction around and at back of structures.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02315 - Excavation.
  - 3. Section 03300 - Cast-in-Place Concrete: Concrete fill.

##### 1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
  - 1. AASHTO M288 - Geotextile Specification.
  - 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 D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m<sup>3</sup>).
  - 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/m<sup>3</sup>).
  - 4. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
  - 5. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
  - 6. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
  - 7. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
  - 8. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data for geotextile fabric indicating fabric and construction.
- C. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of fill to testing laboratory.

- D. Materials Source: Submit name of imported fill materials suppliers.
- E. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

#### 1.4 QUALITY ASSURANCE

- A. Furnish each soil material from single source throughout the Work.
- B. Perform Work in accordance with the drawings and to Engineer's satisfaction.
- C. Maintain one copy on site.

#### 1.5 SEQUENCING

- A. General Requirements: Requirements for sequencing.
- B. Sequence activities shall be as per approved methodology submitted to the Engineer for approval showing all necessary work orders and stages.

### PART 2 PRODUCTS

#### 2.1 FILL MATERIALS

- A. Fill: Conforming to the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality; excavated and reused materials and/or imported borrow materials from approved pits outside the site; selected, graded and free of clay, silt, roots, lumps, rocks, debris, large weeds, organic materials, and any other foreign matter.
  - 1. Plasticity Index should not exceed 12 and liquid limit should not exceed 25 (material passing 0.5mm sieve).
  - 2. Maximum boulder size shall be less than 60% of the permissible layer thickness for backfilling (i.e.: 120mm for 200mm compacted layer thickness).
  - 3. Less than 15% of the elements shall pass the 80 micron sieve.
  - 4. The material shall have the capability to be compacted to a dry density greater than 95% of the Modified Proctor Optimum Density for water content less than 12%.
  - 5. No expansive material shall be permitted.
  - 6. CBR shall be greater than 15 after compacting to 95% of the Modified Proctor Optimum Density with the optimum water content.
  - 7. Tests and Testing Frequency:
    - a. Sieve Analysis: 1 test per 1000 m<sup>3</sup>.
    - b. Modified Proctor: 1 test per 1000 m<sup>3</sup>.
    - c. Liquid Limit: 1 test per 1000 m<sup>3</sup>.
    - d. Plastic Limit: 1 test per 1000 m<sup>3</sup>.
    - e. Optimum Moisture Content: 1 test per 1000 m<sup>3</sup>.
    - f. CBR (Soaked): 1 test per 1000 m<sup>3</sup>.
  - 8. For compaction of material, the moisture content shall be tested to determine the optimum moisture content, and the results shall be submitted to the Engineer for approval prior to use of material.

- B. Concrete Fill: Plain concrete or cyclopean concrete as specified in Section 03300 with cement type and compressive strength as specified and directed by the Engineer.

## 2.2 SOURCE QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and analysis of soil material.
- B. Testing and Analysis of Soil Material: Perform in accordance with ASTM D698 and ASTM D1557.
- C. When tests indicate materials do not meet specified requirements, change material and retest until materials meet the specified requirements.
- D. Furnish materials of each type from approved same source throughout the Work.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.
- C. Verify underground tanks are anchored to their own foundations to avoid flotation after backfilling.
- D. Verify structural ability of unsupported walls to support loads imposed by fill.

### 3.2 PREPARATION

- A. Compact subgrade to density requirements for subsequent backfill materials.
- B. Cut out soft areas of subgrade not capable of compaction in place. Backfill and compact to density equal to or greater than requirements for subsequent fill material.
- C. Scarify subgrade surface to a depth indicated on drawings.
- D. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

### 3.3 EXCAVATED AND BORROW MATERIALS

- A. Excavate soil from on-site approved locations designated by the Engineer as specified in Section 02315, or supply and deliver to site imported borrow materials from approved pits outside the site. Strip soil to full depth in designated areas.
- B. Stockpile excavated and/or imported borrow materials meeting requirements for soil materials.
- C. Remove materials not meeting requirements for soil materials from site.

- D. Remove excess soil materials not intended for reuse, from site.

#### 3.4 STOCKPILING

- A. Stockpile materials on site at locations designated by the Engineer.
- B. Stockpile in sufficient quantities to meet Project schedule and requirements.
- C. Separate differing materials with dividers or stockpile apart to prevent mixing.
- D. Stockpile soil 2.5 m high maximum.
- E. Prevent intermixing of soil types or contamination.
- F. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.
- G. Stockpile unsuitable materials on impervious material and cover to prevent erosion and leaching, until disposed of.

#### 3.5 BACKFILLING

- A. Backfill areas to contours and elevations with approved selected materials.
- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, or spongy subgrade surfaces.
- C. Place fill material in equal continuous layers not exceeding 200 mm compacted thickness, and compact each layer of placed backfilling materials uniformly to achieve minimum 95% of maximum density using Modified Proctor Test Method.
- D. Employ placement method that does not disturb or damage other work.
- E. Maintain optimum moisture content of backfill materials to attain required compaction density.
- F. Backfill against supported foundations.
- G. Backfill simultaneously on each side of unsupported foundations until supports are in place.
- H. Slope grade away from site minimum 50 mm in 3 m, unless directed otherwise.
- I. Make gradual grade changes. Blend slope into level areas.
- J. Remove surplus backfill materials from site.
- K. Leave fill material stockpile areas free of excess fill materials.

### 3.6 STOCKPILE CLEANUP

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

### 3.7 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. General: Finished excavation and fill for permanent works shall be to the lines, levels, and profiles shown on the Contract Drawings with the tolerances specified herein.
- C. Tolerances for Fill (except fill for road embankment):
  - 1. General Fill  $\pm 100\text{mm}$ .
  - 2. Fill to be covered with concrete in foundations or linings, or drainage or filter layers of artificial or selected natural materials, or any layer of other material:  $+0\text{mm}$ ,  $-75\text{mm}$ .
  - 3. The surface tolerance requirements:
    - a. Tolerances along the top edge of any slope steeper than 1 vertical to 30 horizontal shall not vary by more than 10% of the specified slope inclination at any point on the slope.
    - b. Slopes steeper than 1 vertical to 30 horizontal shall not vary by more than 10% of the specified slope inclination at any point on the slope.
- D. Tolerances for Road Excavation and Road Embankment Fill:
  - 1. No point on excavation slopes shall vary from the plane of the design slope by more than 100mm measured at right angles to the slope except for excavation in rock where no point shall vary by more than 500mm.
  - 2. In no case shall any portion of the excavation slope encroach on the roadbed.
  - 3. No point on the completed embankment slope within 1.0 m below shoulder grade shall vary from the plane of the design slope by more than 100 mm measured at right angles to the slope. Slopes more than 1.0 m below shoulder grade shall not vary from than 200 mm measured at right angles to the slope.
  - 4. No point on the completed median and side slopes which are on 1 vertical to 6 horizontal or flatter slopes, whether in excavation or embankment, shall vary from the plane of the design slope by more than 60 mm measured at right angles to the slope. Flow lines within medians shall be graded to drain and shall not vary more than 30 mm from the required grade line.

### 3.8 SETTLEMENT PERIOD

- A. Where a settlement period is shown on Drawings or specified, the permanent fill shall be constructed to full height and to the order limits shown or specified, and shall remain in place for the required settlement period before commencing construction of foundations or placing other layers of materials on the fill surface.
- B. Where a settlement period for a surcharged permanent fill is shown on the Contract Drawings or otherwise specified, the surcharge fill shall be constructed to the height and to the limits shown or specified. The surcharge fill shall remain in place until the end of the settlement period shown or specified.

### 3.9 DUST CONTROL

- A. The Contractor shall use all means necessary to control dust on and near the Work and on and near all borrow areas.
- B. Thoroughly moisten all surfaces as required to prevent dust being a nuisance or a hazard to the public and affect the performance of other work on the site.

### 3.10 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Compaction Trials: Prior to the commencement of Earthwork the Contractor shall construct trial compaction lengths as directed by the Engineer. The soils used in the trials shall be those that will be used for the construction of roads and the compaction equipment to be used shall be that specified in the Contractor's detailed programme of Work and approved by the Engineer. The object of these trials is to determine the best field moisture content of the materials and the relationship between the number of compaction equipment passes and density attained. The Engineer may order additional compaction trials when he deems them necessary.
- C. In situ field density tests should be performed on every 200 mm thick compacted layer each 300 m<sup>2</sup> of layer compacted surface area.
- D. Perform laboratory material tests to ASTM D1557, ASTM D698 and AASHTO T180
- E. Perform in place compaction tests in accordance with the following:
  - 1. Density Tests: ASTM D1556, ASTM D2167, or ASTM D2922.
  - 2. Moisture Tests: ASTM D3017.
- F. When tests indicate Work does not meet specified requirements, remove Work, replace and retest at no additional cost to the Employer.
- G. Frequency of Tests: At the discretion of the Engineer.
- H. Proof roll compacted fill surfaces under slabs-on-grade, and paving.

### 3.11 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished work.
- B. Protect executed backfill form erosion due to effect of storm water or others.
- C. Reshape and re-compact fills subjected to vehicular traffic.

### 3.12 SCHEDULES

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

END OF SECTION

## SECTION 02324

### TRENCHING

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes excavating trenches for utilities; utility bedding and surround; and backfilling and compaction from top of utility cover and around utility structure to subgrade elevations.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02315 - Excavation.
  - 3. Section 02320 - Backfill.
  - 4. Section 03300 - Cast-in-Place Concrete.

##### 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 M288 - Geotextile Specification.
  - 3. 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/m<sup>3</sup>).
  - 3. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
  - 4. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m<sup>3</sup>).
  - 5. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
  - 6. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
  - 7. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
  - 8. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
  - 9. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

##### 1.3 DEFINITIONS

- A. Utility: Any buried pipe, duct, conduit, cable, etc. with fittings, accessories and the like.

#### 1.4 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.
- C. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of fill and aggregate materials to testing laboratory.
- D. Materials Source: Submit name of imported fill materials suppliers.
- E. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

#### 1.5 QUALITY ASSURANCE

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

#### 1.6 QUALIFICATIONS

- A. Prepare excavation protection plan under direct supervision of Professional Engineer experienced in design of this Work and approved by the Engineer.

#### 1.7 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

#### 1.8 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

### PART 2 PRODUCTS

#### 2.1 MATERIALS - GENERAL

- A. Conforming to the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.

## 2.2 COARSE AGGREGATE MATERIALS

- A. Crushed or uncrushed gravel or crushed stone; structurally and chemically stable; free of shale, clay, friable material, debris, impurities, organic matter, or dust; graded to ASTM C136; within the following limits:

1.	<u>Sieve Size</u>	<u>Percent Passing</u>
	50 mm	100
	25 mm	95
	19 mm	95 to 100
	16 mm	75 to 100
	9 mm	55 to 85
	4.75 mm	35 to 60
	1.18 mm	15 to 35
	425 micro m	10 to 25
	75 micro m	5 to 10

## 2.3 FINE AGGREGATE MATERIALS

- A. Clean, sharp, coarse natural sand or sand obtained by crushing gravel or stone; stable in composition (sand from beach, dredging and other sea sources is not allowed); washed; free of organic matter, chemical impurities, silt, clay, loam, friable or soluble materials, and organic matter; graded to ASTM C136; within the following limits:

1.	<u>Sieve Size</u>	<u>Percent Passing</u>
	4.75 mm	100
	1.40 mm	10 to 100
	300 micro m	5 to 90
	150 micro m	4 to 30
	75 micro m	0

## 2.4 BACKFILL MATERIALS

- A. Soil Backfill from Top of Utility Cover and around Utility Structure to Subgrade Elevations: As specified in Section 02320.

## 2.5 ACCESSORIES

- A. Filter Fabric (Geotextile): Non-woven; non-biodegradable; made from polyolefin, polyester, or polyamide; 200 g/m<sup>2</sup>; 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/m<sup>2</sup>.
  5. Apparent Opening Size (ASTM D 4751): 0.095 mm.

## 2.6 SOURCE QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services.
- B. Coarse 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 PREPARATION

- A. Request underground utility information (if any) from relevant authorities not less than three working days before performing Work. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours and datum locations.
- C. Protect plant life, lawns, and other features remaining as portion of final landscaping.
- D. Protect bench marks, existing structures, fences, sidewalks, paving and curbs from excavating equipment and vehicular traffic.
- E. Maintain and protect above and below grade utilities indicated to remain.
- F. Establish temporary traffic control and detours. Relocate controls and reroute traffic as required during progress of Work.
- G. Obtain required permits from authorities having jurisdiction.

### 3.2 TRENCHING

- A. Excavate subsoil required for utilities.
- B. Cut trenches to width indicated on drawings. Remove water or materials that interfere with Work.
- C. Bottom of trenches shall be pipe invert level in addition to the thickness of the pipe and pipe bedding.
- D. Excavate trenches to depth indicated on drawings. Provide uniform and continuous bearing and support for bedding material of utilities.
- E. Do not interfere with 45 degree bearing splay of foundations.
- F. When Project conditions permit, slope side walls of excavation starting **600 mm** above top of pipe. When side walls can not be sloped, provide sheeting and shoring to protect excavation as specified in this section.
- G. When subsurface materials at bottom of trench are loose or soft, notify the Engineer and request instructions, then excavate to greater depth as directed.

- H. Cut out soft areas of subgrade not capable of compaction in place. Backfill with approved fill and compact to density equal to or greater than requirements for subsequent backfill material.
- I. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.
- J. Remove lumped subsoil, boulders and rocks up to **0.25 m<sup>3</sup>** measured by volume, and remove larger solid mineral material with volume in excess of **0.25 m<sup>3</sup>** as follow:
  - 1. Excavate and remove rock by an approved mechanical method. Drill holes and use wedges and mechanical disintegration compound to fracture rock.
  - 2. Cut away rock at bottom of excavation to form level bearing.
  - 3. Provide sound and unshattered base for foundations.
  - 4. Remove excavated materials from site to approved dumps.
- K. Correct areas over excavated with compacted backfill as specified for authorized excavation or replace with plain concrete as specified in Section 03300 and as directed by the Engineer.
- L. Remove excess subsoil not intended for reuse, from site.
- M. Stockpile excavated material intended for reuse in approved area on site in accordance with Section 02320.

### 3.3 SHEETING AND SHORING

- A. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion and loss of surrounding subsoil.
- B. Support trenches more than **1000 mm** deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.
- C. Design sheeting and shoring to be left in place as part of the completed Work, cut off minimum **450 mm** below finished grade or to be removed at completion of work.
- D. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.
- E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

### 3.4 COARSE AND FINE AGGREGATE MATERIALS

- A. Supply and deliver to site aggregate materials; grade and test to approved standards.
- B. Stockpile material meeting requirements for coarse and fine aggregate materials.
- C. Remove from site materials not meeting requirements for aggregate materials.
- D. Remove from site excess materials not intended for reuse.

### 3.5 STOCKPILING

- A. Stockpile materials on site at locations indicated or designated by Engineer.
- B. Stockpile in sufficient quantities to meet Project schedule and requirements.
- C. Separate different materials with dividers or stockpile individually to prevent mixing.
- D. Stockpile material to a maximum height of 2.5 m.
- E. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.
- F. Upon completion of works, remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

### 3.6 BACKFILLING

- A. Backfilling of pipe trenches (except at joints) shall be done as soon as practicable after the pipes have been satisfactorily laid in position and jointed and in no case shall more than five pipe lengths be left uncovered after laying. Where shown on drawings, the first stage of the backfill, up to 300 mm above the crown of the pipe, shall consist of selected coarse and/or fine aggregate material, as shown on the drawings. The selected aggregate material shall be free draining and readily compactable. This backfill shall be spread in layers, each not exceeding 150 mm in thickness after compaction to required density.
- B. The remainder of the pipe trench (from 300 mm above the crown of the pipe to the sub-base coarse of the road or to the top of the trench) shall be backfilled with selected fill materials, after the completion of testing, by one of the following methods:
  - 1. Where the pipeline crosses or runs underneath roads or pavements, backfilling shall be placed in layers not exceeding 200 mm after compaction, and wetted as necessary and compacted to required density.
  - 2. In open areas, backfilling may be done with excavated material dumped into the trench, provided that the fill material does not contain any large stones, that the trench is completely filled without leaving any voids, and the fill is finished with a neat mound raised to about 300 mm above the trench edges to allow for future subsidence.
- C. Employ placement method that does not disturb or damage utilities in trench.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.
- E. All joints and other accessories shall be left uncovered until after the pipeline shall have passed successfully the specified pressure and/or leakage tests.
- F. Where the backfill cover above the pipe is less than 700 mm. The travel of the tracks or wheels of heavy equipment thereon will be strictly prohibited, and the Contractor shall use suitable small compactor, and shall be responsible for any damage caused to the pipe by non compliance with this requirement.

- G. Protect open trench to prevent danger to the public.
- H. The Contractor shall be responsible for any subsidence of trench backfill and shall make good any damage to road or structures caused thereby during the Period of Maintenance.
- I. Where lengths of trench are excavated partly in rock, stony ground, or in other material unsuitable for backfilling, there may not be sufficient suitable material available from the excavation for backfilling as specified above and in such cases the Contractor shall transport suitable material from other parts of the work or from borrow areas.
- J. The Contractor shall make arrangements for sites for tipping the spoil and include in his rates for excavation the cost of haulage and tipping of spoil and all expenses in connection with the obtaining of suitable backfilling material.

### 3.7 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Top Surface of Backfilling: Plus or minus 5 mm from required elevations.

### 3.8 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and Execution requirements for testing, adjusting and balancing.
- B. Perform laboratory material tests in accordance with ASTM D1557 or ASTM D698.
- C. Perform in place compaction tests in accordance with the following:
  - 1. Density Tests: ASTM D1556, ASTM D2167, or ASTM D2922.
  - 2. Moisture Tests: ASTM D3017.
- D. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest until Work meets the specified requirements.

### 3.9 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished work.
- B. Reshape and re-compact fills subjected to vehicular traffic during construction.

### 3.10 SCHEDULE

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

END OF SECTION

## SECTION 02339

### SUB-GRADE PREPARATION

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes grading and compacting surfaces under foundations, slab on grade base slabs, rigid pavement, and under flexible pavement.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02315 - Excavation.
  - 3. Section 02320 - Backfill.

##### 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.
- 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/m<sup>3</sup>).
  - 3. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
  - 4. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m<sup>3</sup>).
  - 5. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
  - 6. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
  - 7. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head).
  - 8. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
  - 9. 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 procedures.
- B. Samples: Submit 4.5 kg sample of each type of fill 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 PERFORMANCE REQUIREMENTS

- A. The 200 mm depth of embankment subgrade layer immediately below the bottom of the aggregate sub base layer shall consist of selected material having a 4-day soaked CBR of not less than 20 when tested in accordance with AASHTO T-193 when compacted at 100% of modified proctor AASHTO (T-180-D) and having a maximum PI of 12. Subgrade gradation shall be reasonably smooth without gap grading. All material shall pass the 75 mm sieve and not more than 18% shall pass the 0.075 mm (No. 200) sieve.
- B. The 600 mm depth of embankment immediately below the subgrade layer shall consist of material having a 4-day soaked CBR of at least 15 when compacted to 95% maximum dry density in accordance with AASHTO T-180D and tested in accordance with AASHTO T-193 with a PI not more than 15. If rockfill is used for the bottom 400 mm then these requirements shall apply to the top 200 mm below the subgrade layer.

#### 1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

#### 1.6 QUALITY ASSURANCE

- A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.
- B. Perform Work in accordance with the drawings and to the satisfaction of the Engineer.
- C. Maintain one copy of each document on site.

### PART 2 PRODUCTS

#### 2.1 MATERIALS

- A. Fill: As specified in Section 02320.

#### 2.2 SOURCE QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and testing and analysis of soil material.
- B. Testing and Analysis of Subsoil and Topsoil Materials: Perform in accordance with ASTM D698, ASTM D1557 and/or AASHTO T180.
- C. When tests indicate materials do not meet specified requirements, change material and retest.
- D. Furnish materials of each type from approved same source throughout the Work.

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## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify site conditions under provisions of relevant authorities' standard.
- C. Verify survey bench mark and intended elevations for the Work are as indicated on Drawings.

### 3.2 PREPARATION

- A. Identify required lines, levels, contours and datum.
- B. Protect utilities indicated to remain from damage (if any).
- C. Protect plant life, lawns and other features remaining as portion of final landscaping.
- D. Protect bench marks, survey control point, existing structures, fences, sidewalks, paving and curbs from compacting equipment and vehicular traffic.

### 3.3 EXCAVATION AND FILLING (WHERE REQUIRED)

- A. Excavate soil from areas to be further excavated, relandscaped, or regraded.
- B. Do not excavate wet soil or excavate and process wet material to obtain optimum moisture content.
- C. When excavating through roots, perform Work by hand and cut roots with sharp axe.
- D. Remove excavated materials from site and cart away to approved dumping areas.
- E. Benching Slopes: Horizontally bench existing slopes greater than 1:4 to key placed fill material to slope to provide firm bearing.
- F. Stability: Replace damaged or displaced soil as specified for fill.
- G. Fill areas to contours and elevations with unfrozen selected materials.
- H. Place fill material in continuous layers and compact to achieve specified density; perform compaction in accordance with Section 02320.
- I. Slope grade away from construction areas, minimum 1.5%, unless noted otherwise.
- J. Make grade changes gradual. Blend slope into level areas.
- K. Repair or replace items indicated to remain damaged by excavation or filling.

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### 3.4 SUB-GRADE PREPARATION

- A. Compact all surfaces to receive foundations, slab on grade and base slabs, flexible pavement and rigid pavement; perform compaction as per Section 02320.
- B. Maintain optimum moisture content of substrate to attain required compaction density
- C. Install Work in accordance with the drawings and to the satisfaction of the Engineer.

### 3.5 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Top Surface of Subgrade: Plus or minus 5 mm from required elevation.

### 3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Perform laboratory material tests in accordance with ASTM D1557, ASTM D698 and/or AASHTO T180.
- C. Perform in place compaction tests in accordance with the following:
  - 1. Density Tests: ASTM D1556, ASTM D2167, or ASTM D2922.
  - 2. Moisture Tests: ASTM D3017.
- D. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

### 3.7 SCHEDULES

- A. Sub-Grade Preparation: Compact uniformly to minimum 95% of maximum density using Modified Proctor Test Method and as specified in Section 02320.

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/m<sup>3</sup>).
  - 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/m<sup>3</sup>).
  - 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 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 if shown on 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 to AASHTO T-27 after dry mixing and just before spreading and compacting. The granular material class 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 (№ 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:

<b>Control on Site after Laying and Compaction</b>	
<b>Required Tests</b>	<b>Frequency</b>
1. Proctor 2. Gradation of Materials 3. Plasticity Index 4. CBR 5. Abrasion 6. Sand equivalent 7. Clay lumps & friable particles 8. Field Density	<ul style="list-style-type: none"> <li>• Test for every 500 m for each layer and lane width, when material source or process changes and when otherwise instructed by the Engineer,</li> </ul>
9. Thickness	<ul style="list-style-type: none"> <li>• Test for every 1000 m<sup>2</sup> and for every layer</li> </ul>

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:

<b>Control on Site after Laying and Compaction</b>	
<b>Required Tests</b>	<b>Frequency</b>
1. Proctor 2. Gradation of Materials 3. Plasticity Index 4. CBR 5. Abrasion 6. Sand equivalent 7. Clay lumps & friable particles 8. Field Density	<ul style="list-style-type: none"> <li>• Test for every 500 m for each layer and lane width and when material source or properties changed</li> </ul>
9. Thickness	<ul style="list-style-type: none"> <li>• Test for every 1000 m<sup>2</sup> and for every layer</li> </ul>

### 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 02952

### PIPE AND MANHOLE TESTING

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Testing Manholes: Vacuum Test.
  - 2. Testing Gravity Sewer Piping: Low-Pressure Air Test and Infiltration Test.
  - 3. Hydrostatic Testing Pressure Piping.
  - 4. Deflection Testing of Plastic Pipe.
- B. Related Sections:
  - 1. Section 02082 - Manholes and Structures.
  - 2. Section 02513 - Water Distribution Systems.
  - 3. Section 02536 - Pressure Sewer System (Force Mains).
  - 4. Section 02539 - Sanitary Sewer Systems.

##### 1.2 REFERENCES

- A. ASTM International:
  - 1. ASTM C1244M - Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test (Metric).
  - 2. ASTM D2122 - Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Submit the following prior to start of testing:
  - 1. Testing procedures.
  - 2. List of test equipment.
  - 3. Testing sequence schedule.
  - 4. Provisions for disposal of flushing and test water.
  - 5. Certification of test gauge calibration.
  - 6. Deflection mandrel drawings and calculations.
- C. Test Reports: Indicate results of manhole and piping tests.

#### PART 2 PRODUCTS

##### 2.1 VACUUM TESTING EQUIPMENT

- A. Vacuum pump.
- B. Vacuum line.

- C. Vacuum tester base with compression band seal and outlet port.
- D. Shut-off valve.
- E. Stop watch.
- F. Plugs.
- G. Vacuum gauge, calibrated to 0.34 kPa.

## 2.2 AIR TEST EQUIPMENT

- A. Air compressor.
- B. Air supply line.
- C. Shut-off valves.
- D. Pressure regulator.
- E. Pressure relief valve.
- F. Stop watch.
- G. Plugs.
- H. Pressure gauge, calibrated to 0.69 kPa.

## 2.3 INFILTRATION TEST EQUIPMENT

- A. Weirs.

## 2.4 HYDROSTATIC TEST EQUIPMENT

- A. Hydro pump.
- B. Pressure hose.
- C. Water meter.
- D. Test connections.
- E. Pressure relief valve.
- F. Pressure gauge, calibrated to 0.69 kPa.

## 2.5 DEFLECTION TEST EQUIPMENT

- A. Go, No-Go mandrels.
- B. Pull/retrieval ropes.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify piping and manholes are ready for testing.
- C. Verify pressure piping concrete reaction support blocking or mechanical restraint system is installed.

### 3.2 PIPING PREPARATION

- A. Lamping:
  - 1. Lamp gravity piping after flushing and cleaning.
  - 2. Perform lamping operation by shining light at one end of each pipe section between manholes; observe light at other end; reject pipe not installed with uniform line and grade; remove and reinstall rejected pipe sections; re-clean and lamp until pipe section achieves uniform line and grade.
- B. Plug outlets, wye-branches and laterals; brace plugs to resist test pressures.

### 3.3 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Testing Manholes:
  - 1. General: Test using air whenever possible prior to backfilling to assist in locating leaks. Make joint repairs on both outside and inside of joint to ensure permanent seal. Test manholes with manhole frame set in place.
  - 2. Vacuum test in accordance with ASTM C1244 and as follows:
    - a. Plug pipe openings; securely brace plugs and pipe.
    - b. Inflate compression band to effect seal between vacuum base and structure; connect vacuum pump to outlet port with valve open; draw vacuum to 33.8 kPa; close valve; start test.
    - c. Test:
      - 1) Determine test duration for manhole from the table below:  
VACUUM TEST TABLE

<u>Manhole Diameter</u>	<u>Test Period</u>
1.2 meters	60 seconds
1.5 meters	75 seconds
1.8 meters	90 seconds
      - 2) Record vacuum drop during test period; when vacuum drop is greater than 3.4 kPa during test period, repair and retest manhole; when vacuum drop of 3.4 kPa does not occur during test period, discontinue test and accept manhole.
      - 3) When vacuum test fails to meet 3.4 kPa drop in specified time after repair, repair and retest manhole.

3. When unsatisfactory test results are achieved, repair manhole and retest until result meets criteria; repair visible leaks regardless of quantity of leakage.

C. Testing Gravity Sewer Piping:

1. Low-pressure Air Test:

- a. Test each section of gravity sewer piping between manholes.
- b. Introduce air pressure slowly to approximately 28 kPa.
  - 1) Determine ground water elevation above spring line of pipe, for every foot of ground water above spring line of pipe increase starting air test pressure by 3.0 kPa; do not increase pressure above 69 kPa.
- c. Allow pressure to stabilize for at least five minutes. Adjust pressure to 24 kPa or increased test pressure as determined above when ground water is present. Start test.
- d. Test:
  - 1) Determine test duration for sewer section with single pipe size from the following table. Do not make allowance for laterals.

**AIR TEST TABLE**

**Minimum Test Time for Various Pipe Sizes**

Nominal Pipe Size, (mm)	T (time), (min/ 30 m)
75	0.2
100	0.3
150	0.7
200	1.2
250	1.5
300	1.8
375	2.1
450	2.4
525	3.0
600	3.6
675	4.2
750	4.8
825	5.4
900	6.0

- 2) Record drop in pressure during test period; when air pressure has dropped more than 6.89 kPa during test period, piping has failed; when 6.89 kPa air pressure drop has not occurred during test period, discontinue test and piping is accepted.
  - 3) When piping fails, determine source of air leakage, make corrections and retest; test section in incremental stages until leaks are isolated; after leaks are repaired, retest entire section between manholes.
2. Test pipe larger than 900 mm diameter with exfiltration test not exceeding 378 liters for each mm of pipe diameter for each kilometer per day for each section under test. Perform test with minimum positive head of 610 mm.
  3. Infiltration Test:
    - a. Use only when gravity piping is submerged in groundwater minimum of 1220 mm above crown of pipe for entire length being tested.

- b. Maximum Allowable Infiltration: 378 liters per mm of pipe diameter for each kilometer per day for section under test; include allowances for leakage from manholes. Perform test with minimum positive head of 610 mm.
- D. Testing Pressure Piping:
- 1. Hydrostatic Leakage Test:
    - a. Hydrostatically test each portion of pressure piping, including valves, at 1.5 times working pressure of piping based on elevation of lowest point in piping corrected to elevation of test gauge.
    - b. Fill section to be tested with water slowly, expel air from piping at high points. Install corporation cocks at high points. Close air vents and corporation cocks after air is expelled. Raise pressure to specified test pressure.
    - c. Observe joints, fittings and valves under test. Remove and renew cracked pipe, joints, fittings, and valves showing visible leakage. Retest.
    - d. Correct visible deficiencies and continue testing at same test pressure for additional 2 hours to determine leakage rate. Maintain pressure within plus or minus 34.4 kPa of test pressure. Leakage is defined as quantity of water supplied to piping necessary to maintain test pressure during period of test.
    - e. Compute maximum allowable leakage "L" by the following formula:
$$L = \frac{SD\sqrt{P}}{C}$$
Where "S" is the length of pipe tested, in meters;  
"D" is the nominal diameter of pipe, in mm;  
"P" is the average test pressure during leakage test, in kPa;  
"C" is a constant equal to 22,259.  
When pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.
    - f. When test of pipe indicates leakage greater than allowed, locate source of leakage, make corrections and retest until leakage is within allowable limits. Correct visible leaks regardless of leakage quantity.
- E. Deflection Testing of Plastic Pipe:
- 1. Perform vertical ring deflection testing on plastic piping, after backfilling has been in place for at least 30 days but not longer than 12 months.
  - 2. Allowable maximum deflection for installed plastic pipe limited to five percent (5%) of original vertical internal diameter.
  - 3. Perform deflection test using properly sized rigid ball or 'Go, No-Go' mandrel
  - 4. Furnish rigid ball or mandrel with diameter not less than 95 percent of base or average inside diameter of pipe as determined by ASTM standard to which pipe is manufactured. Measure pipe in compliance with ASTM D2122.
  - 5. Perform test without mechanical pulling devices.
  - 6. Locate, excavate, replace and retest pipe exceeding allowable deflection.

END OF SECTION

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## 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/m<sup>2</sup>, 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

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## 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.

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## 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.

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## 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 03100 - Concrete Forms and Accessories.
  - 2. Section 03200 - Concrete Reinforcement.
  - 3. Section 07130 - Sheet Waterproofing.
  - 4. Section 07140 - Fluid-Applied Waterproofing.
  - 5. Section 07900 - Joint Sealers.
  - 6. Division 15 - Mechanical: Mechanical items for casting into concrete.
  - 7. 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 (SO<sub>3</sub>) 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 ( $\text{SO}_3$ ) 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/m<sup>3</sup>.

## 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, and roofing membrane 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 ( $\pm 20$ mm) (mm)	Maximum Water to Cement Ratio	Minimum Cement Content (kg/m <sup>3</sup> )	Notes
		cylinders (MPa)	cubes (MPa)				
Blinding.	Type II	14	18	180	0.60	250	Normal mix
Reinforced concrete foundations, retaining walls, channels, slabs and ramps on grade, walls, stairs on grade, grade beams and tank walls.	Type II	30	38	180	0.42	350	Normal mix
Reinforced concrete columns, beams, solid slabs, upstands and pads below tanks and solar structure.	Type II	30	38	180	0.42	350	Normal 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 m<sup>3</sup>) 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/mm<sup>2</sup>.
- G. If any strength test of laboratory-cured cylinders falls below specified value ( $f'c$ ) by more than 3.5 N/mm<sup>2</sup> 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/mm<sup>2</sup> 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 (centre 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 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.

### 3.11 COMPACTION OF CONCRETE

- A. All concrete shall be compacted to produce a dense homogeneous mass. Unless otherwise agreed 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 mixer be interrupted the vibrators should be lifted clear from work.
- E. Care shall be taken to ensure that concrete is fully compacted around waterstops without distorting, displacing or damaging the waterstops.

### 3.12 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.

### 3.13 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.

### 3.14 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.

### 3.15 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.

### 3.16 PROTECTION TO SUBSTRUCTURE

- A. Waterproofing membrane shall be provided where indicated on the drawings. Waterproofing membrane and roofing 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.

### 3.17 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. Once 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.

### 3.18 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.

### 3.19 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.

### 3.20 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.

### 3.21 SCHEDULES

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

END OF SECTION

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## SECTION 03930

### CONCRETE REHABILITATION

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Concrete reinforcement repair.
  - 2. Concrete surface repair.
  - 3. Concrete crack repair.
- B. Related Sections:
  - 1. Section 03200 - Concrete Reinforcement.
  - 2. Section 03300 - Cast-in-Place Concrete.

##### 1.2 REFERENCES

- A. ASTM International:
  - 1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
  - 2. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
  - 3. ASTM A996/A996M - Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.
  - 4. ASTM C33 - Standard Specification for Concrete Aggregates.
  - 5. ASTM C109/C109M - Standard Test Method for Compressive strength of Hydraulic Cement Mortars (Using 2-in. or (50 mm) Cube Specimens).
  - 6. ASTM C150 - Standard Specification for Portland Cement.
  - 7. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
  - 8. ASTM C293 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading).
  - 9. ASTM C404 - Standard Specification for Aggregates for Masonry Grout.
  - 10. ASTM C882 - Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear.
  - 11. ASTM C1042 - Standard Test Method for Bond Strength of Latex Systems Used With Concrete by Slant Shear.
  - 12. ASTM D638 - Standard Test Method for Tensile Properties of Plastics.
  - 13. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics.
  - 14. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
- B. American Welding Society:
  - 1. AWS D1.4 - Structural Welding Code - Reinforcing Steel.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.

- B. Product Data: Submit product standards, physical and chemical characteristics, technical specifications, limitations, maintenance instructions, and general recommendations regarding each material.
- C. Samples: Submit color samples for patches exposed to view in finished construction and required to match existing.
- D. Manufacturer's Instructions: Submit mixing instructions.
- E. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

#### 1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.
- B. Project Record Documents: Accurately record actual locations of structural reinforcement repairs, and type of repair.
- C. Operation and Maintenance Data: Procedures for submittals.

#### 1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with the drawings, to the manufacturer's instructions and to the approval of the Engineer.
- B. Maintain one copy of each document on site.
- C. Perform welding work in accordance with AWS D1.4.

#### 1.6 QUALIFICATIONS

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

#### 1.7 MOCK-UP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup panel size as directed by the Engineer, illustrating patching method, color and texture of repair surface.
- C. Prepare one mockup for each type of injection and patching procedure.
- D. Locate where directed by the Engineer.
- E. Remove mockup when directed by the Engineer.

## 1.8 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for product storage and handling.
- B. Comply with instructions for storage, shelf life limitations, and handling.

## PART 2 PRODUCTS

### 2.1 CONCRETE REHABILITATION

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

### 2.2 EPOXY ADHESIVE INJECTION MATERIALS

- A. Epoxy Adhesive: Two-part epoxy adhesive containing 100 percent solids, meeting the following minimum characteristics:

	<u>Characteristic</u>	<u>Test Method</u>	<u>Results</u>
1.	Bond Strength	ASTM C882	18.6 MPa
2.	Tensile Strength	ASTM D638	45.5 MPa
3.	Elongation	ASTM D638	2 % @ 7 days, 21°C
4.	Flexural Strength	ASTM D790	55.2 MPa
5.	Compressive Strength	ASTM D695	44.8 MPa

### 2.3 EPOXY MORTAR MATERIALS

- A. Epoxy Mortar: Three-part epoxy binding resin and aggregate mortar mixture.
- B. Epoxy Binding Resin: Two-part epoxy resin containing 100 percent solids, meeting the following minimum characteristics:

	<u>Characteristic</u>	<u>Test Method</u>	<u>Results</u>
1.	Bond Strength	ASTM C882	18.6 MPa
2.	Tensile Strength	ASTM D638	45.5 MPa
3.	Elongation	ASTM D638	2 % @ 7 days, 21°C
4.	Flexural Strength	ASTM D790	55.2 MPa
5.	Compressive Strength	ASTM D695	44.8 MPa

- C. Aggregate: Type recommended by mortar manufacturer.

### 2.4 CEMENTITIOUS MORTAR MATERIALS

- A. Cementitious Mortar: Packaged latex modified, silica fume enhanced, and/or Portland cement or hydraulic cement patching mortar with the following properties:
  - 1. Compressive Strength: ASTM C109/C109M; minimum 14 MPa after one day and 34 MPa after 28 days.
  - 2. Bond Strength: ASTM C882 and ASTM C1042; minimum 10 MPa after 28 days.
  - 3. Flexural Strength; ASTM C293; minimum 10.3 MPa after 28 days.
- B. Portland Cement: ASTM C150, Type I, unless otherwise indicated, color as selected.

- C. Sand: ASTM C33 and/or ASTM C404; uniformly graded, clean.
- D. Water: Clean and potable.
- E. Air Entrainment Admixture: ASTM C260.
- F. Calcium Chloride: Not permitted.
- G. Bonding Agent: Polyvinyl acetate emulsion, dispersed in water while mixing, non-coagulant in mix, water resistant when cured.
- H. Cleaning Agent: Commercial muriatic acid.

## 2.5 REINFORCEMENT MATERIALS

- A. Reinforcing Steel: As specified in Section 03200.
- B. Stirrup Steel: As specified in Section 03200.
- C. Splicing Sleeves: As indicated on the drawings in accordance with Section 03200.

## 2.6 MIXING EPOXY MORTAR

- A. Mix epoxy mortars to consistency for purpose intended.
- B. Mix components in clean equipment or containers. Conform to pot life and workability limits.

## 2.7 MIXING CEMENTITIOUS MORTAR

- A. Mix cementitious mortar to consistency required for purpose intended.
- B. Include bonding agent as additive to mix.

# PART 3 EXECUTION

## 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify surfaces are ready to receive work.
- C. Beginning of installation means acceptance of existing surfaces and/or substrate.

## 3.2 PREPARATION

- A. Clean concrete surfaces of dirt, laitance, corrosion, or other contamination; wire brush using water and/or acid; rinse surface and allow to dry.

- B. Flush out cracks and voids with chemical solvent, muriatic acid and/or water to remove laitance and dirt. Chemically neutralize by rinsing with water.
- C. Provide temporary entry ports spaced to accomplish movement of fluids between ports; no deeper than depth of crack to be filled or port size diameter no greater than thickness of crack. Provide temporary seal at concrete surface to prevent leakage of adhesive.
- D. For areas patched with epoxy mortar, remove broken and soft concrete 6 mm deep. Remove corrosion from steel. Clean surfaces mechanically; wash with acid; rinse with water.
- E. Sandblast clean exposed reinforcement steel surfaces. Mechanically cut away damaged portions of bar.

### 3.3 REPAIR WORK

- A. Repair reinforcement by welding new bar reinforcement to existing reinforcement with and/or sleeve splices. Strength of welded splices and reinforcement to exceed original stress values.
- B. Repair exposed structural, shrinkage, and settlement cracks of concrete as indicated on Drawings, by epoxy injection, epoxy application and/or bonding agent and cementitious paste method.
- C. Repair spalling, fill voids flush with surface, and/or Apply surface finish.

### 3.4 INJECTION - EPOXY RESIN

- A. Inject epoxy resin adhesive into prepared ports under pressure using equipment appropriate for particular application.
- B. Begin injection at lower entry port and continue until adhesive appears in adjacent entry port. Continue from port to port until entire crack is filled.
- C. Remove temporary seal and excess adhesive.
- D. Clean surfaces adjacent to repair and blend finish.

### 3.5 APPLICATION - EPOXY MORTAR

- A. Trowel apply mortar mix to required and indicated thickness. Tamp into place filling voids at spalled areas.
- B. For patching honeycomb, trowel mortar onto surface, work mortar into honeycomb to bring surface flush with surrounding area. Finish trowel surface to match surrounding area.
- C. Cover exposed steel reinforcement with epoxy mortar, feather edges to flush surface.

3.6 APPLICATION - CEMENTITIOUS MORTAR

- A. Apply, spray, brush and/or roller coating of bonding agent to dry and/or damp concrete surfaces. Provide full surface coverage.
- B. Apply cementitious mortar by steel trowel to required and indicated thickness. Tamp into place filling voids at spalled areas. Work mix into honeycomb.
- C. Damp cure cementitious mortar for four days.

3.7 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing, inspection and analysis.
- B. Test concrete for calcium chloride content during execution of the Work.

3.8 SCHEDULE

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

END OF SECTION

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## 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 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”, 9<sup>th</sup> 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/m<sup>2</sup> 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:

<b>Number of Pieces to Be Used from Identified Package</b>	<b>Number of Specimens</b>
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
  2. A minimum of three pieces from each lot shall be tested.
  3. 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. 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 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 m<sup>2</sup> 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. 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.

- B. 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

- C. Seaming Materials: As recommended by membrane manufacturer.
- D. 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.

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## 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 m<sup>2</sup> 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/m<sup>2</sup> each for horizontal surfaces, and 1000 g/m<sup>2</sup> 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.

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### 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, 1.5 kg/m<sup>2</sup> in two coats minimum, unless otherwise directed.

## 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