



The World Bank



Republic of Lebanon



Council for Development  
and Reconstruction

**THE GREEN AGRI-FOOD TRANSFORMATION FOR  
ECONOMIC RECOVERY PROJECT (GATE)**

**COMPLEMENTARY WORKS FOR THE EXPANSION OF  
THE SEWAGE COLLECTION NETWORK TO CONNECT TO  
THE ZAHLE WASTEWATER TREATMENT PLANT AND  
AITANIT WASTEWATER TREATMENT PLANT**

**ICB №: GC2W2C**

**VOLUME 2 – TECHNICAL SPECIFICATIONS**

**PART 1 – TECHNICAL SPECIFICATIONS RELEVANT TO  
THE ZAHLE WORKS**

**SEPTEMBER 2026**



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## 1- DESCRIPTION OF WORK AND SITE

### 1-1 The Works

#### 1-1-1 General Description

This Specification covers the construction and completion of the "**LAKE QARAOUN POLLUTION PREVENTION PROJECT – Remaining Works Related to Expansion of Sewage Network to Connect to Zahle Wastewater Treatment Plant - Lebanon**" project, as shown on the Drawings, Bill of Quantities, and as detailed in the Contract Documents and directed by the Engineer.

The project is located as shown on drawings.

The Contract comprises the 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 permanent nature required for the execution and completion of the works.

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.

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.

The "Technical Specifications" are prepared based on the Construction Specifications Institute (CSI) master format. The numbers and titles of the Technical Specifications Sections 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.

#### 1-1-2 The Works

The Works consist of the construction and completion of "**LAKE QARAOUN POLLUTION PREVENTION PROJECT – Remaining Works Related to Expansion of Sewage Network to Connect to Zahle Wastewater Treatment Plant - Lebanon**" project.

The works shall include but not limited to the following Networks:

| Networks                             | Pipeworks | Manholes | House Connections |
|--------------------------------------|-----------|----------|-------------------|
| ➤ Zahle - El Ferzol Sewer Network    | 59,225 lm | 1,537 №  | 1,000 №           |
| ➤ Saadnyael - Taalbaya Sewer Network | 3,420 lm  | 147 №    | 80 №              |
| ➤ Quaa El Rim Sewer Network          | 9,440 lm  | 384 №    | 345 №             |
| ➤ Hezzerta Sewer Network             | 15,390 lm | 589 №    | 350 №             |

The works cover the following main elements:

- Cutting, Breaking Out and Reinstatement of Existing Paved Surfaces
- Breaking Out and Reinstatement of Existing Unpaved Surfaces
- Trench Excavation for Gravity Sewer System
  - Trench Excavation for Gravity Sewer Pipes under Paved or Unpaved Surfaces (to Be Backfilled with Selected Fill Materials)
  - Trench Excavation for Gravity Sewer Pipes under Paved Surfaces (to Be Backfilled with Sand Fill Materials up to Formation Level below Aggregate Sub-Base Course as per the Regulations of the Ministry of Public Works)

- Trench Excavation for Gravity Sewer Pipes in Water Course (to be backfilled with borrow pit material as indicated on the drawings)
- Pipes for Gravity Sewer Systems
  - Pipes for New Gravity Sewer Network
  - Pipes to Replace Existing Gravity Sewer Network including temporary diversion of existing sewerage
- Sand Material for Pipe Bedding and Surroundings
- Reinforced Concrete Encasement for Pipes under Paved or Unpaved Surfaces
- Concrete Encasement for Pipes in Water Course
- Reinforced Concrete Manholes and Chambers
- Backdrop Connections to Manholes
- Connection of Existing/New Pipes to New/Existing Manholes
- Bridge crossing of pipe run

**1-1-2-1 Delete Clause No 5-5-3 and Clause No 5-5-4**

Delete Clause No 5-5-3 (Representative's Vehicles) and Clause No 5-5-4 (Vehicle Driver) in Division 1 - General Requirements / Section 5 - Temporary Works and Services, and consequently these Clauses are NOT APPLICABLE.

## SECTION 02060

### AGGREGATE

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes coarse and fine aggregate materials.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02315 - Excavation.
  - 3. Section 02320 - Backfill.
  - 4. Section 02324 - Trenching.
  - 5. Section 02511 - Water Storage Tank and Pumping Station.
  - 6. Section 02513 - Water Distribution Systems.
  - 7. Section 02515 - Water Service Connections.
  - 8. Section 02533 - Wastewater Pumping Stations.
  - 9. Section 02536 - Pressure Sewer System (Force Mains).
  - 10. Section 02539 - Sanitary Sewer Systems.
  - 11. Section 02631 - Stormwater Drainage Systems.
  - 12. Section 02721 - Aggregate Sub-Base and Base Courses.

##### 1.2 REFERENCES

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

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal.
- B. Samples: Submit, in air-tight containers, 4.5 kg sample of each type of fill to testing laboratory.

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

#### 1.4 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.

### PART 2 PRODUCTS

#### 2.1 COARSE AGGREGATE MATERIALS - GENERAL

- A. Conforming to the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.
- B. Crushed or uncrushed gravel or crushed stone; structurally and chemically stable; free of shale, clay, friable material, debris, impurities, organic matter, or dust; graded in accordance with 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                |

#### 2.2 FINE AGGREGATE MATERIALS - GENERAL

- A. Conforming to the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.
- B. Clean sharp, coarse natural sand or sand obtained by crushing suitable 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 in accordance with 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                      |

## 2.3 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 GENERAL

- 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.

### 3.2 STOCKPILING

- A. Stockpile materials on site at locations indicated or designated by the Engineer.
- B. Stockpile in sufficient quantities to meet Project schedule and requirements.
- C. Separate different aggregate materials with dividers or stockpile individually to prevent mixing.
- D. Stockpile soil 2.5 m high maximum.
- E. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

### 3.3 STOCKPILE CLEANUP

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

END OF SECTION

## 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, Fire Hydrants and Valve Boxes.
  - 2. Section 02233 - Breaking Out and Reinstatement.
  - 3. Section 02315 - Excavation.
  - 4. Section 02320 - Backfill.
  - 5. Section 02511 - Water Storage Tank and Pumping Station.
  - 6. Section 02513 - Water Distribution Systems.
  - 7. Section 02515 - Water Service Connections.
  - 8. Section 02533 - Wastewater Pumping Stations.
  - 9. Section 02536 - Pressure Sewer System (Force Mains).
  - 10. Section 02539 - Sanitary Sewer Systems.
  - 11. Section 02631 - Stormwater Drainage Systems.
  - 12. Section 02662 - Sewer Manhole and Structure Liners.
  - 13. Section 02952 - Pipe and Manhole Testing.
  - 14. Section 03100 - Concrete Forms and Accessories.
  - 15. Section 03200 - Concrete Reinforcement.
  - 16. 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.
- C. Liner to Internal Surfaces of Sewer Manholes and Structures: As specified in Section 02662.

## 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. Install liner to internal surfaces of sewer manholes and structures as specified in section 02662.
- K. 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 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 02233 - Breaking Out and Reinstatement.
  - 2. Section 02315 - Excavation.
  - 3. Section 02320 - Backfill.
  - 4. Section 02324 - Trenching.

##### 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.

## 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 obtrude, 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 40 mm 1½ inches 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 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.

### 3.8 SCHEDULES

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

END OF SECTION

## SECTION 02233

### BREAKING OUT AND REINSTATEMENT

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Breaking out of existing paved road surfaces in bituminous courses, concrete, or pavers of any type, and reinstatement to match existing.
  - 2. Breaking out of existing unpaved surfaces in granular material, or in aggregate sub-base or base course, of any type and any thickness, and reinstatement to match existing.
  - 3. Removing resulting materials and cleaning.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02339 - Sub-Grade Preparation.
  - 3. Section 02721 - Aggregate Base Course.
  - 4. Section 02740 - Flexible Pavement.
  - 5. Section 02750 - Rigid Pavement.
  - 6. Section 02783 - Precast Concrete Pavers.
  - 7. Section 02784 - Stone Pavers.
  - 8. Section 03300 - Cast-In-Place Concrete.

##### 1.2 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Breaking out Schedule: Indicate overall schedule and interruptions required for utilities and services.
- C. Shop Drawings: Indicate Breaking out, reinstatement and removal sequences, and indicate (if any) location and construction of temporary work.

##### 1.3 QUALITY ASSURANCE

- A. Perform Work as per drawings and to the satisfaction of the Engineer.
- B. Conform to applicable code for environmental requirements, dust control and disposal of debris.
- C. Obtain required permits from authorities having jurisdiction.
- D. Maintain one copy of each document on site.

##### 1.4 PRE-INSTALLATION MEETINGS

- A. General Requirements: Administrative requirements for pre-installation meeting.

- B. Convene minimum one week prior to commencing work of this section.

## 1.5 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.

## 1.6 SCHEDULING

- A. General Requirements: Administrative requirements and network analysis schedules for scheduling requirements.
- B. Cooperate with Owner in scheduling noisy operations and waste removal that may impact other and Owners operation in adjoining spaces.
- C. Perform noisy, malodorous and dusty works between hours and on days approved by the Engineer.

# PART 2 PRODUCTS

## 2.1 MATERIALS

- A. Reinstatement of Paved Road Surfaces:
  - 1. Aggregate Sub-Base and Base Courses: In accordance with Section 02721.
  - 2. Flexible Pavement: In accordance with Section 02740.
  - 3. Rigid Pavement: To match existing and in accordance with Section 02750.
  - 4. Pavers of any type: To match existing.
- B. Reinstatement of Unpaved Surfaces:
  - 1. Aggregate Sub-Base and Base Courses: In accordance with Section 02721.

# PART 3 EXECUTION

## 3.1 PREPARATION

- A. Notify local utility information service not less than three working days before performing Work and comply with their requirements.
- B. Prevent spreading of dust, odors and noise.
- C. Do not close or obstruct roadways and sidewalks without permits.
- D. Provide all necessary temporary works and remove upon completion of Work.
- E. Protect bench marks and survey control points from damage or displacement.
- F. Clear areas required to be broken out and reinstated as specified in Section 02230.

- G. Carry out Work in orderly and careful manner.
- H. Reinstatement works shall match previously existing and shall be carried out to the satisfaction of the Engineer.

### 3.2 BREAKING OUT AND REINSTATEMENT OF PAVED ROAD SURFACES

- A. Remove, store in approved locations and replace upon completion all street lamps, roads signs, road marking, safety barriers and all other street furniture. Any defective street furniture shall be replaced with a new similar one.
- B. Remove and replace upon completion any form and any type of structures.
- C. Break out and reinstate to match previously existing upon completion all bituminous courses, concrete, aggregate sub-base and/or base courses, paving, curbs and the like. Neatly saw cut edges at right angle to surface.

### 3.3 BREAKING OUT AND REINSTATEMENT OF UNPAVED SURFACES

- A. Remove, store in approved locations and replace upon completion all barriers and all other furniture. Any defective furniture shall be replaced with a new similar one.
- B. Remove and replace upon completion any form and any type of structures.
- C. Break out and reinstate to match previously existing upon completion all granular material, aggregate sub-base or base course, of any type and any thickness.

### 3.4 CLEANING

- A. Continuously clean-up and remove waste materials from site and cart away to approved dumping areas.
- B. Do not allow materials to accumulate on site.
- C. Do not burn or bury materials on site.
- D. Upon completion of Work, leave areas in clean condition to the satisfaction of the Engineer.

### 3.5 SCHEDULES

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

END OF SECTION

## SECTION 02315

### EXCAVATION

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes soil 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 02233 - Breaking Out and Reinstatement.
  - 3. Section 02320 - Backfill.
  - 4. Section 02324 - Trenching.

##### 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.

## 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; 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 foundations, at back of walls, etc.
- 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 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.

## 2.3 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 with structural fill 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. Where shown on the drawings, place geotextile fabric over fill prior to placing next lift of fill.
- D. 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.
- E. Employ placement method that does not disturb or damage other work.
- F. Maintain optimum moisture content of backfill materials to attain required compaction density.

- G. Backfill against supported foundations.
- H. Backfill simultaneously on each side of unsupported foundations until supports are in place.
- I. Slope grade away from site minimum 50 mm in 3 m, unless directed otherwise.
- J. Make gradual grade changes. Blend slope into level areas.
- K. Remove surplus backfill materials from site.
- L. 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 in accordance with ASTM D1557, ASTM D698, and/or 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; 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 gravel or 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:

| <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:

| <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 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 material. Selected 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 and suitable 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. Protect open trench to prevent danger to the public.
- G. 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.
- 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 pans 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.

### 3.5 TOLERANCES

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

### 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 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.

### 3.7 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.

### 3.8 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 aggregate sub-base and base courses.
- 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 submittals 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, 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.

## 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.

### 3.4 SUB-GRADE PREPARATION

- A. Compact all surfaces to receive aggregate sub-base and base courses; perform compaction in accordance with 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 as specified in Section 02320.

END OF SECTION

## SECTION 02539

### SANITARY SEWER SYSTEMS

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Sanitary sewer pipe and fittings.
  - 2. Underground pipe markers / warning detectable tape.
  - 3. Bedding and cover materials.
  - 4. Concrete protection, encasement, and thrust blocks.
  - 5. Connection to existing manholes.
  - 6. Manholes.
  - 7. Wye branches and tees.
  - 8. Sanitary laterals.
- 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 03200 - Concrete Reinforcement.
  - 7. Section 03300 - Cast-in-Place Concrete.

##### 1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
  - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. ASTM International:
  - 1. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
  - 2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
  - 3. ASTM A746 - Standard Specification for Ductile Iron Gravity Sewer Pipe.
  - 4. ASTM C14M - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric).
  - 5. ASTM C76M - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric).
  - 6. ASTM C443M - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets (Metric).
  - 7. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
  - 8. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (5,600 kN.m/m<sup>3</sup>).
  - 9. ASTM C923M - Standard Specification for Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric).

10. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (2,700 kN.m/m<sup>3</sup>).
11. ASTM D1785 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.
12. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
13. ASTM D2321 - Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
14. ASTM D2466 - Standard Specification for Poly Vinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40.
15. ASTM D2564 - Standard Specification for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems.
16. ASTM D2729 - Standard Specification for Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
17. ASTM D2751 - Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
18. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings.
19. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
20. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
21. ASTM D3034 - Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
22. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

C. American Water Works Association:

1. AWWA C104 - American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
2. AWWA C105 - American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
3. AWWA C110 - American National Standard for Ductile-Iron and Grey-Iron Fittings, 3 in. through 48 in. (75 mm through 1200 mm), for Water and Other Liquids.
4. AWWA C111 - American National Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
5. AWWA C150 - ANSI Standard for the Thickness Design of Ductile Iron Pipe.
6. AWWA C151 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
7. AWWA C153 - American National Standard for Ductile-Iron Compact Fittings for Water Service.

D. National Fire Protection Association:

1. NFPA 24 - Installation of Private Fire Service Mains and Their Appurtenances.

### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.

- B. Permits: Obtain and submit to the Engineer all necessary permits from authorities having jurisdiction.
- C. Shop Drawings: Indicate layout of sewer system and appurtenances. Show size, materials, components of system and burial depth.
- D. Product Data: Submit catalogs and other pertinent data indicating proposed materials, accessories, details and construction information.
- E. Submit reports indicating field tests made and results obtained.
- F. Manufacturer's Installation Instructions:
  - 1. Indicate special procedures required to install Products specified.
  - 2. Submit detailed description of procedures for connecting new sewer to existing sewer line.
- G. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

#### 1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Record location of pipe runs, connections, manholes and invert elevations.
- C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

#### 1.5 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.

#### 1.6 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. Deliver and store valves in shipping containers with labeling in place.
- C. Block individual and stockpiled pipe lengths to prevent moving.
- D. Avoid shock or damage to pipe and take measures to prevent damage to exterior surface or internal lining of pipe.

## 1.9 FIELD MEASUREMENTS

- A. Verify field measurements and elevations are as indicated.

## 1.10 COORDINATION

- A. General Requirements: Administrative requirements for coordination.
- B. Coordinate the Work with all relevant authorities.

# 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, as shown on the drawings and to the satisfaction of the Engineer.

## 2.2 SANITARY SEWER PIPE AND FITTINGS

- A. Ductile Iron Pipe: AWWA C150, AWWA C151 and ASTM A746, or K9 as per ISO/BS standards, Extra Heavy or Service type, Class 50, 52, 54, or above, bell and spigot or plain ends.
  - 1. Outside Coating: AWWA C151, asphaltic coating, 1 mil uniform thickness.
  - 2. Lining:
    - a. Cement mortar lined in accordance with AWWA C104, with 3 layers of coal tar epoxy.
    - b. SewperCoat lined with seal coating applied to lining:
      - 1) 3.0 mm thick for pipe sizes 6 through 12 inches.
      - 2) 4.8 mm thick for pipe sizes 14 through 24 inches.
    - c. AWWA C104, asphaltic seal coat, 1 mil minimum uniform thickness.
  - 3. Polyethylene Encasement for Pipe Installation in Corrosive Soils: AWWA C105.
  - 4. Fittings: AWWA C153 or AWWA C110, ductile iron, Class 50, 52, 54, or above cement mortar lined in accordance with AWWA C104 or SewperCoat lined and coated with bituminous paint.

5. Coat pipe and fittings exposed inside of structures as per manufacturer's recommendations.
  6. Mechanical Joints: AWWA C111, rubber gasket joint devices.
- B. Concrete Pipe: ASTM C14M, Class 3; bituminous or coal tar epoxy coated internally; un-reinforced; inside nominal diameter as shown on drawings, bell and spigot or plain ends.
1. Fittings: Concrete pipe, ASTM C14M.
  2. Joints: ASTM C443M, rubber compression gasket.
- C. Reinforced Concrete Pipe: ASTM C76M, Class III, IV, or V with Wall Type B, or C; bituminous or coal tar epoxy coated or HDPE sheet lining internally; mesh or bar reinforcement; inside nominal diameter as shown on drawings; bell and spigot or plain ends.
1. Fittings: Reinforced concrete.
  2. Joints: ASTM C443M, rubber compression gasket.
- D. Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe: ASTM D2751, SDR 23.5, 35 or 42; inside nominal diameter as per drawings, bell and spigot style solvent sealed ends.
1. Fittings: ABS.
  2. Joints: ASTM D2235, solvent weld.
- E. Poly Vinyl Chloride (PVC) Plastic Pipe Up to 300 mm Diameter: ASTM D3034, SDR 35 minimum; inside nominal diameter as shown on drawings, bell and spigot style solvent sealed joint ends.
1. Fittings: ASTM D2466, PVC.
  2. Joints: ASTM D2855, or equivalent as per EN/ISO standards.
- F. Poly Vinyl Chloride (PVC) Plastic Pipe Exceeding 300 mm Diameter:
1. ASTM D2729; inside nominal diameter as shown on drawings, bell and spigot solvent sealed ends.
    - a. Fittings: PVC.
    - b. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
  2. ASTM D3034, Type PSM; inside nominal diameter as shown on drawings, bell and spigot style rubber ring sealed gasket joint.
    - a. Fittings: PVC.
    - b. Joints: ASTM F477, elastomeric gaskets.
- G. Unplasticized Poly Vinyl Chloride (uPVC) Plastic Pipes, Fittings and Joints: BS-EN 1401-1; inside nominal diameter as shown on drawings.
- H. Glass Fiber Reinforced Plastic (GRP) Pipe: BS 5480: Parts 1 and 2; minimum specific tangential initial stiffness for gravity and pressure pipes shall be STIS 5000; rating for pressure pipes shall be as indicated on the drawings but not less than 10 bar; inside nominal diameter as shown on drawings; use of pipes with integral sockets will not be permitted.
1. Fittings: GRP.
  2. Joints: Separate collar type.

### 2.3 FLEXIBLE COUPLINGS

- A. Flexible Coupling: Resilient chemical-resistant elastomeric polyvinyl chloride (PVC) coupling, two stainless steel clamps and stainless steel screws and housings.

### 2.4 FLEXIBLE PIPE BOOT FOR MANHOLE PIPE ENTRANCES

- A. Flexible Pipe Boot: ASTM C923M, ethylene propylene rubber (EPDM), stainless steel clamp and stainless steel hardware.

### 2.5 PIPE SUPPORTS

- A. Metal for pipe support brackets: ASTM A123/A123M, galvanized structural steel thoroughly coated with bituminous paint.

### 2.6 UNDERGROUND PIPE MARKERS/WARNING DETECTABLE TAPE

- A. Trace Wire for Pipe: Magnetic detectable conductor, clear or brightly colored plastic covering, continuously imprinted with "Sewer Service" in large letters and in accordance with relevant authorities' standards. Sample to be submitted to the Engineer for approval.

### 2.7 PIPE BEDDING AND COVER MATERIAL

- A. Pipe Bedding and Cover: Granular or sand as specified in Section 02324.

### 2.8 CONCRETE PROTECTION, ENCASEMENT AND THRUST BLOCKS

- A. Concrete: Conforming to Section 03300, reinforced concrete, strength in MPa at 28 day as directed by the Engineer, air entrained, rough troweled finish.
- B. Concrete Reinforcement: Conform to Section 03200.
- C. Accessories: 50 mm thick expandable polystyrene board; 30 kg/m<sup>3</sup> minimum board density; board width ranging from pipe diameter to trench width.

### 2.9 MANHOLES

- A. Manholes: Conform to Section 02082.
- B. Manhole Cover: Inscribed with "Sewer Service" and in accordance with relevant authorities' standards.

### 2.10 BACKFILL MATERIALS

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

## PART 3 EXECUTION

### 3.1 EXAMINATION

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

### 3.2 PREPARATION

- A. Correct over excavation with lean concrete.
- B. Remove large stones or other hard matter capable of damaging pipe or impeding consistent backfilling or compaction.
- C. Protect and support existing sewer lines, utilities and appurtenances.
- D. Maintain profiles of utilities. Coordinate with other utilities to eliminate interference. Notify the Engineer where crossing conflicts occur.

### 3.3 EXCAVATION

- A. Excavate pipe trench in accordance with Section 02324.
- B. Excavate to lines and grades shown on Drawings or required to accommodate installation of encasement.
- C. Dewater excavations to maintain dry conditions and preserve final grades at bottom of excavation.
- D. Provide sheeting and shoring in accordance with Section 02324.

### 3.4 INSTALLATION - PIPE BEDDING

- A. Place bedding material at trench bottom, level materials in continuous layer 200 mm compacted depth unless otherwise shown on drawings; compact to 98 percent as specified in Section 02324.
- B. Maintain optimum moisture content of bedding material to attain required compaction density.

### 3.5 LINES AND GRADES

- A. Lay pipes to lines and grades indicated on Drawings. The Engineer reserves the right to make necessary changes in utility lines, grades and depths for Project conditions.
- B. Maintain grade alignment of pipe using string line parallel with grade line and vertically above centerline of pipe.

### 3.6 INSTALLATION - PIPE

- A. Install pipe, fittings and accessories in accordance with ASTM D2321. Seal joints watertight.
- B. Place pipe on bedding material.
- C. Lay pipe to slope gradients noted on drawings; with maximum variation from indicated slope of 3 mm in 3 m. Begin at downstream end and progress upstream. Connect pipe to sewer manholes or structures.
- D. Assemble and handle pipe in accordance with manufacturer's instructions except as modified on the Drawings or by the Engineer.
- E. Keep pipe and fittings clean until work is completed and accepted by the Engineer. Cap open ends during periods of work stoppage.
- F. Lay bell and spigot pipe with bells upstream.
- G. Polyethylene Pipe Encasement in Corrosive Soil Conditions: AWWA C105, Method A or B.
- H. Install detectable underground utility marking tape, continuous, above pipe center line, over pipe cover as shown on drawings; coordinate with Section 02320.
- I. Install Work in accordance with the drawings and to the satisfaction of the Engineer.

### 3.7 INSTALLATION - CONNECTION TO EXISTING MANHOLE

- A. Core drill existing manhole to clean opening. Using pneumatic hammers, chipping guns, sledge hammers.
- B. Install watertight neoprene gasket and seal with approved non-shrink concrete grout.
- C. Concrete encase new sewer pipe minimum of 600 mm to nearest pipe joint. Use epoxy binder between new and existing concrete.
- D. Prevent construction debris from entering existing sewers when making connection.

### 3.8 INSTALLATION - PIPE COVER

- A. Install pipe cover materials at sides and over top of pipe as specified in Section 02324. Compact to 98 percent dry density by weight.
- B. Maintain optimum moisture content of bedding material to attain required compaction density.
- C. Do not displace or damage pipe when compacting.

### 3.9 INSTALLATION - CONCRETE PROTECTION, ENCASEMENT & THRUST BLOCKS

- A. Provide and install where directed and/or indicated on Drawings concrete protection, encasement, and thrust blocks in accordance with section 03300.
- B. Where concrete protection is to be placed in trenches over pipe cover, lay over pipe crown during pipe cover installation, horizontal expandable polystyrene boards.
- C. Install thrust blocks at dead ends, if any, of gravity sewer lines.

### 3.10 INSTALLATION - MANHOLES

- A. Install manholes in accordance with Section 02082.

### 3.11 INSTALLATION - WYE BRANCHES AND TEES

- A. Install wye branches or pipe tees at locations indicated on Drawings concurrent with pipe laying operations. Use standard fittings of same material and joint type as sewer main.
- B. Maintain minimum 1.5 m separation distance between wye connection and manhole.
- C. Use saddle wye or tee with stainless steel clamps for taps into existing piping. Mount saddles with solvent cement or gasket and secure with metal bands. Layout holes with template and cut holes with mechanical cutter.

### 3.12 INSTALLATION - SANITARY LATERALS

- A. Construct laterals directly from manhole or from wye branch to terminal point.
- B. Where depth of main pipeline warrants, construct riser type laterals from wye branch. Maintain 600 mm minimum depth of cover over pipe.
- C. Maintain minimum 1.5 meter separation distance between laterals.
- D. Install watertight plug, braced to withstand pipeline test pressure thrust, at termination of lateral. Install temporary marker stake extending from end of lateral to 300 mm above finished grade. Paint top 150 mm of stake with fluorescent orange paint.

### 3.13 BACKFILLING

- A. Backfill above pipe cover to finished grade in accordance with Section 02320.
- B. Maintain optimum moisture content of bedding material to attain required compaction density.

### 3.14 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Pressure, Infiltration and Deflection Tests: Test in accordance with Section 02952.

- C. Request inspection prior to and immediately after placing pipe cover.
- D. Compaction Testing: In accordance with Section 02324.
- E. When tests indicate Work does not meet specified requirements, remove work, replace and retest.

### 3.15 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished Work.
- B. Protect pipe and pipe cover materials from damage or displacement prior, during and until backfilling operation is complete. Repair pipe that is damaged or displaced.

### 3.16 SCHEDULE

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

END OF SECTION

## SECTION 02662

### SEWER MANHOLE AND STRUCTURE LINERS

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes fiber reinforced epoxy liners to internal surfaces of sewer structures.
- B. Related Sections:
  - 1. Section 02082 - Manholes and Structures.
  - 2. Section 02533 - Wastewater Pumping Stations.
  - 3. Section 02539 - Sanitary Sewer Systems.
  - 4. Section 02952 - Pipe and Manhole Testing.
  - 5. Section 03300 - Cast-in-Place Concrete.

##### 1.2 REFERENCES

- A. ASTM International.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Shop Drawing: Show joining details and special details.
- C. Product Data: Submit data on liner.
- D. Samples: Submit two samples of liner material, **500 x 1000 mm** in size illustrating finish, color and texture.
- E. Manufacturer's Installation Instructions: Submit special procedures for liner installation.
- F. Manufacturer's Certificates: Certify Products meet or exceed specified requirements.

##### 1.4 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for submittals.
- B. Project Record Documents: Accurately record actual pipe penetration locations.

##### 1.5 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.

## 1.6 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. Transport and handle liner with equipment designed to protect liner from damage.
- C. Store products in dry areas. Protect from contact with soil and exposure to elements.
- D. Keep products dry.
- E. Store adhesive between 15°C and 26°C.
- F. Do not use materials damaged during storage or handling. Do not use adhesive exposed to temperatures of 4 degrees C for more than 24 hours.

## 1.9 ENVIRONMENTAL REQUIREMENTS

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

## 1.10 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

## 1.11 WARRANTY

- A. General Requirements: Execution requirements for warranties.
- B. Furnish five year manufacturer's warranty for repair or replacement of liners that leak or fail in materials and workmanship or that deteriorate under conditions of normal weather. Warranty shall also include deterioration or failure of liner due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena. Warranty does not include deterioration or failure of liner due to fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.

## PART 2 PRODUCTS

### 2.1 MATERIALS

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

### 2.2 FIBER REINFORCED EPOXY LINER

- A. One layer of an approved coal tar pitch epoxy coating, 200 microns thick, as per manufacturer's instructions.
- B. One layer of approved fiberglass reinforcements as per manufacturer's instructions, thickness ranging from 3 to 4 mm.
- C. Another two layers of the approved coal tar pitch epoxy coating, 200 microns thick each, as per manufacturer's instructions.
- D. One approved plastic panel facing (if shown on drawings) as per manufacturer's instructions, thickness ranging from 2 to 3 mm.

### 2.3 ACCESSORIES

- A. Adhesives and Solvents: Types recommended by liner manufacturer for bonding to structures, for sealing seams in geomembrane, and for sealing projections through liner.
- B. Penetration Assemblies: Manufacturer's standard factory-fabricated assemblies for sealing penetrations for utilities and structures.

### 2.4 FABRICATION

- A. Fabricate liner panels from sheets in sizes as large as possible with factory-sealed seams, consistent with limitations of weight and installation procedures. Minimize field seaming.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify substrate is clean and dry, and without any holes, lips, angular ridges, and unstable sandy areas which may affect the performance of liner.

### 3.2 PREPARATION

- A. Prepare surfaces to receive liner in accordance with the recommendations of the manufacturer. Substrate shall be even, free from dust, dirt, moisture and any matter which may puncture the liner, and to manufacturer's instructions.

### 3.3 INSTALLATION

- A. Prepare the surfaces including sandblasting and air cleaning.
- B. Apply one layer of an approved coal tar pitch epoxy coating, 200 microns thick, as per manufacturer's recommendations.
- C. Place one layer of approved fiberglass reinforcements before the applied epoxy coating is completely dry, as per manufacturer's recommendations.
- D. Apply another two layers of the approved coal tar pitch epoxy coating, 200 microns thick each.
- E. Place (if shown on drawings) plastic panel facing with approved adhesive materials.

### 3.4 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements and execution requirements for field inspecting, testing, adjusting and balancing.
- B. Inspect seams and repaired areas to ensure tight, continuously bonded installation. Repair damaged liner and seams and reinspect repaired work.

### 3.5 PROTECTION OF FINISHED WORK

- A. General Requirements: Execution requirements for protecting finished Work.
- B. Protect installed liner according to liner manufacturer's instructions. Repair or replace areas of liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

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

#### 4. Table-1: Grading of Granular Material by Class:

| Sieve Designation<br>(Square Openings) | Percent by Weight Passing |         |
|----------------------------------------|---------------------------|---------|
|                                        | Class A                   | Class B |
| 50 mm (2 in.)                          | –                         | 100     |
| 25 mm (1 in.)                          | 100                       | 75 – 95 |
| 9.5 mm (3/8 in.)                       | 30 – 65                   | 40 – 75 |
| 4.75 mm (No. 4)                        | 25 – 55                   | 30 – 60 |
| 2.00 mm (No. 10)                       | 15 – 40                   | 20 – 45 |
| 0.425 mm (No. 40)                      | 8 – 20                    | 15 – 30 |
| 0.075 mm (No. 200)                     | 2 – 8                     | 5 – 20  |

5. The material shall contain a maximum 5% clay content at any stage of construction when tested in the Hydrometer Test in accordance with AASHTO T88.
6. The loss in weight of granular material shall not exceed 50% after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Abrasion Test).
7. The granular material shall have a 4-day soaked CBR of not less than 30 when compacted at 100% of modified proctor AASHTO (T180-D) and tested in accordance with AASHTO T193.
8. When tested for soundness in accordance with AASHTO T104, the material shall not show signs of disintegration and the percentage loss in weight after 5 cycles shall not exceed 12 % in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.
9. The portion of granular material, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (LL) of not more than 25 and a plasticity index (PI) not greater than 6 when tested in accordance with AASHTO T 89 and T 90.

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

B. Aggregates for Base Course:

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

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

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

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

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

## 2.2 SOURCE QUALITY CONTROL AND TESTS

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

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

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

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

| <b>Control on Site after Laying and Compaction</b>                                                                                                                     |                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Required Tests</b>                                                                                                                                                  | <b>Frequency</b>                                                                                                                                      |
| 1. Proctor<br>2. Gradation of Materials<br>3. Plasticity Index<br>4. CBR<br>5. Abrasion<br>6. Sand equivalent<br>7. Clay lumps & friable particles<br>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 02740

### FLEXIBLE PAVEMENT

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes asphaltic concrete binder and wearing courses, and surface sealer.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02233 - Breaking Out and Reinstatement.
  - 3. Section 02320 - Backfill.
  - 4. Section 02339 - Sub-Grade Preparation.
  - 5. Section 02721 - Aggregate Sub-Base and Base Courses.

##### 1.2 REFERENCES

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

##### 1.3 SUBMITTALS

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

##### 1.4 QUALITY ASSURANCE

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

## 1.5 QUALIFICATIONS

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

## 1.6 ENVIRONMENTAL REQUIREMENTS

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

## PART 2 PRODUCTS

### 2.1 MATERIALS - GENERAL

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

### 2.2 BITUMINOUS PRIME AND TACK COATS

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

### 2.3 AGGREGATES FOR BITUMINOUS PAVING MIXES

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

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

- H. The flakiness index and the elongation index tests shall be conducted in accordance with BS EN 933-3:1997 with the following maximum limits:

|                       | <b>Wearing Course</b> | <b>Binder and Base Course</b> |
|-----------------------|-----------------------|-------------------------------|
| Flakiness Index (FI). | 20                    | 35                            |
| Shape Index (SI).     | 25                    | 30                            |

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

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

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

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

## 2.4 BITUMEN PRODUCTS

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

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

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

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

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

## 2.5 BITUMINOUS BASE COURSE

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

## 2.6 BITUMINOUS WEARING COURSE

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

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

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

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

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

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

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

## 2.7 ASPHALT PAVING MIX

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

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

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

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

## 2.8 SPEED BUMPS

- A. Tack Coat: Liquid asphalt for tack coat shall be rapid curing type cutback grades RC-250 or RC-3000 as directed, and shall conform to the relevant requirements of Bituminous Prime and Tack Coats.
- B. Bituminous Mix: The bituminous mix for speed bumps shall conform to the relevant requirements of Bituminous Binder and Wearing Courses for a wearing course mix unless otherwise shown on the Drawings.

## 2.9 SOURCE QUALITY CONTROL AND TESTS

- A. General Requirements: Quality requirements for testing, inspection and analysis requirements.
- B. Submit proposed mix design of each mix class for review prior to beginning of Work.
- C. Test samples in accordance with AI MS-2, and in accordance with the standards and regulations of the relevant local authorities having jurisdiction and/or Municipality.

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

| Item                                                | Tests at Source of Materials                                                                                                                                                                                                                                        | Frequency                                                                                                                                                |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Materials used in Asphalt Mix at Batching plant     | <ol style="list-style-type: none"> <li>1. Specific Gravity and Water Absorption.</li> <li>2. Absorption Test.</li> <li>3. Chert content.</li> <li>4. Clay Lumps and Friable Particles.</li> <li>5. Flaky and Elongated Particles.</li> <li>6. Soundness.</li> </ol> | For each source, and when material quality changes, and when requested by the Engineer                                                                   |
| Materials Used in Asphalt Mix from Hot Bins         | <ol style="list-style-type: none"> <li>1. Gradation.</li> <li>2. Specific Gravity and Water Absorption.</li> <li>3. Plasticity Index.</li> <li>4. Sand Equivalent.</li> <li>5. Stripping with Asphalt.</li> </ol>                                                   | For each source, and when material quality changes, and when requested by the Engineer                                                                   |
| Asphalt Mix Design for Each Layer at Batching Plant | <ol style="list-style-type: none"> <li>1. Complete Mix Design.</li> <li>2. Loss of Stability.</li> </ol>                                                                                                                                                            | For each Project, and when material quality changes, and when results are not consistent with the mix design results, and when requested by the Engineer |
| Asphalt for Each Layer at Batching Plant            | <ol style="list-style-type: none"> <li>1. Stability.</li> <li>2. Flow.</li> <li>3. Binder Content &amp; Gradation.</li> <li>4. Air Voids.</li> <li>5. Voids in Mineral Aggregates.</li> <li>6. Daily Marshall Density.</li> </ol>                                   | Every 3 working days, and for each batching plant, and when requested by the Engineer                                                                    |
|                                                     | <ol style="list-style-type: none"> <li>7. Loss of Stability.</li> </ol>                                                                                                                                                                                             | Every week, and when requested by the Engineer                                                                                                           |

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

| Item                   | Test at Road Site                                                                                                                                                                                                                            | Frequency                                                                      |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Asphalt for Each Layer | Behind Spreader: <ol style="list-style-type: none"> <li>1. Stability.</li> <li>2. Flow.</li> <li>3. Binder Content &amp; Gradation.</li> <li>4. Air Voids.</li> <li>5. Voids in Mineral Aggregates.</li> <li>6. Marshall Density.</li> </ol> | Every working day, and Test for each batch, and when requested by the Engineer |
|                        | Core Samples: <ol style="list-style-type: none"> <li>7. Density and Thickness.</li> <li>8. Bitumen Penetration Grade Verification.</li> </ol>                                                                                                | Every 200m per lane, and each layer, and when requested by the Engineer        |

- F. The Marshall Bulk specific gravity shall be determined in accordance with AASHTO T166. The Marshall specimens shall be prepared from the same material used in the construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the Site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.

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

## PART 3 EXECUTION

### 3.1 EXAMINATION

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

### 3.2 BITUMINOUS PRIME AND TACK COATS

- A. Construction of Trial Sections:
  - 1. The Engineer shall, if necessary, instruct trial sections to be constructed prior to the commencement of on-site prime or tack coat applications. The Contractor shall construct trial sections using varying application rates of bitumen as selected by the Engineer. Each trial section shall be two lanes wide by 50 meters long, at approved locations on or close to the Site.
  - 2. Each trial section shall be constructed using the same materials, mixing and spraying equipment and construction procedures proposed for use in the Works.
  - 3. The objectives of these trials shall be to determine the adequacy of the Contractor's equipment and the most suitable application rates for cutback bitumen prime and tack coats.
  - 4. The Contractor shall not proceed with site coat applications until the methods and procedures established in the trials have been approved by the Engineer.

B. General Application Procedures:

1. All equipment used for surface cleaning, heating bitumen and application of prime and tack coats shall be suitable for the purposes intended and shall be approved by the Engineer before use.
2. All surfaces to receive prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned using power brooms or power blowers. Surfaces shall be approved before applying any bitumen material.
3. Prime coats and tack coats shall be applied only when the surface to be treated is sufficiently dry for tack coats and sufficiently moist for prime coats and when the ambient temperature is above 10°C for the application of tack coat and above 15°C for the application of prime coat. Prime and tack coats shall not be applied during fog, rain, strong winds, generally dusty conditions or dust storms.
4. The surfaces of all structures, curbs, gutters and other highway appurtenances shall be protected from being splattered or stained with bitumen or damaged during equipment operation. The Contractor shall be responsible for making good any such staining or damage to the satisfaction of the Engineer.
5. Traffic shall not be permitted on surfaces cleaned and prepared for prime or tack coat application.
6. If there are undue delays in applying prime or tack coats or subsequent paving thereafter, the surface tolerances and compaction of the granular course shall be re-verified, the deficient areas shall be corrected and/or replaced, and the prime and tack coats shall be re-applied in accordance with the Engineer's instructions and at the Contractor's expense.
7. The Contractor shall maintain prime coats and tack coats intact until they are covered by the subsequent pavement course. Any area where the coats have been damaged shall be cleaned of all loose material, all surface defects shall be repaired, and the coat shall be re-applied at the Contractor's expense.

C. Prime Coat Application:

1. If required by the Engineer, when the surface is an untreated subgrade or a granular surface, the cleaned surface shall be given a light application of water and allowed to dry to the condition deemed appropriate by the Engineer before the bituminous material is applied.
2. Heating of MC cutback bitumen and its temperature at the time of application shall be as specified.
3. Areas to be primed shall be as shown on the Drawings and shall include 200 mm wide outside the edges of the pavement.
4. Application rates for prime coat shall be determined by the Engineer from the trial sections and shall be generally within the following ranges:
  - a. Untreated subgrade surfaces, shoulders base course: 0.75-2.0 liter/m<sup>2</sup>.
  - b. Bridge wearing surfaces, concrete pavements: 0.1 - 0.4 liter/m<sup>2</sup>.
  - c. Other Surfaces: As determined from field tests or trials.
5. The Engineer may order additional trial sections and/or alter the previously established rates of application during progress of the Works.
6. Prime coat shall be applied using pressure distributors operated by skilled workmen. The spray nozzles and spray bar shall be adjusted and frequently checked so that a uniform distribution is ensured. Spraying shall cease immediately if any nozzle ceases to spray and corrective measures shall be taken before spraying is resumed.

7. Hand spraying shall be used only for priming small patches or inaccessible areas that cannot be primed by normal operation of the pressure distributor.
8. Application of prime coat between separate areas of priming shall not be excessive. Any excess prime coat shall be removed from the surface using clean sand to blot excess primer, and any skipped areas or recognized deficiencies shall be corrected using hand sprays.
9. When required by the Engineer, a light covering of blotting material shall be applied to the prime coat 48 hours after spraying and when it has not dried sufficiently to withstand damage by traffic. The blotting material shall be a smooth fine sand or other material approved by the Engineer.
10. Prime coats shall be cured for 3 days before traffic is allowed on it or before the succeeding pavement layer is placed, or as directed by the Engineer.

D. Tack Coat Application:

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

### 3.3 PLACING ASPHALT PAVEMENT - SINGLE COURSE

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

### 3.4 PLACING ASPHALT PAVEMENT - DOUBLE COURSE

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

### 3.5 SPEED BUMPS

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

### 3.6 TOLERANCES

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

### 3.7 FIELD QUALITY CONTROL

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

### 3.8 PROTECTION OF FINISHED WORK

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

END OF SECTION

## SECTION 02750

### RIGID PAVEMENT

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes concrete pavement for roads, sidewalks, etc.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02233 - Breaking Out and Reinstatement.
  - 3. Section 02320 - Backfill.
  - 4. Section 02339 - Sub-Grade Preparation.
  - 5. Section 02721 - Aggregate Sub-Base and Base Courses.
  - 6. Section 02740 - Flexible Pavement.
  - 7. Section 03100 - Concrete Forms and Accessories.
  - 8. Section 03200 - Concrete Reinforcement.
  - 9. Section 03300 - Cast-in-Place Concrete.
  - 10. Section 07900 - Joint Sealers: Sealant for joints.
  - 11. Section 09900 - Paints and Coatings: Pavement markings.

##### 1.2 REFERENCES

- A. American Concrete Institute:
  - 1. ACI 301 - Specifications for Structural Concrete.
  - 2. ACI 304 - Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- B. ASTM International:
  - 1. ASTM A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
  - 2. ASTM A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
  - 3. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
  - 4. ASTM C33 - Standard Specification for Concrete Aggregates.
  - 5. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
  - 6. ASTM C150 - Standard Specification for Portland Cement.
  - 7. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
  - 8. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
  - 9. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.
  - 10. ASTM C1315 - Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
  - 11. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

12. ASTM D1752 - Standard Specification for Preformed Sponge Rubber and  
Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

1.3 PERFORMANCE REQUIREMENTS

- A. Concrete Pavement: Designed to suit project requirements and conditions, and in accordance with relevant authorities' standards.

1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data on joint filler, admixtures and curing compounds.

1.5 QUALITY ASSURANCE

- A. Perform Work as per ACI 301, as shown on drawings and to Engineer's satisfaction.
- B. Maintain one copy of each document on site.
- C. Obtain cementitious materials from same source throughout.

1.6 QUALIFICATIONS

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

1.7 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup 1500x1500mm including paving, joints, surface texture and finish.
- C. Locate where directed by the Engineer.
- D. Remove mockup when directed by the Engineer.

1.8 PRE-INSTALLATION MEETINGS

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

1.9 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements for environmental conditions affecting products.
- B. Do not place concrete when ambient temperature is less than 5°C.

## PART 2 PRODUCTS

### 2.1 FORM MATERIALS

- A. Form Materials: Conform to ACI 301, and as specified in Section 03100.
- B. Joint Filler: ASTM D1751, or ASTM D1752; to manufacturer's recommendations.

### 2.2 REINFORCEMENT

- A. Reinforcing Steel and Wire Fabric: As specified in Section 03200.

### 2.3 CONCRETE MATERIALS

- A. Concrete Materials and Admixtures: As specified in Section 03300.
- B. Concrete Finishes: Brushed, non-skid, as specified in Section 03350.
- C. Exposed Aggregate (If Required): Quartz, marble, limestone, or gravel; washed natural mineral aggregate from same single source; size from 4.75 mm to 19.0 mm; color as selected.

### 2.4 ACCESSORIES

- A. Vapor Retarders: Polyethylene film for above grade application, 0.25 mm thick.
- B. Curing Compound: ASTM C309, Type 1, 1D, or 2, Class A, or B; or membrane curing compound to ASTM C1315 Type I or II, Class A, B or C.
- C. Liquid Surface Sealer: To manufacturer's recommendations.
- D. Surface Retarder: To manufacturer's recommendations; color as selected from manufacturer's standard range.
- E. Joint Sealers: To manufacturer's recommendations.

### 2.5 CONCRETE MIX

- A. Concrete Mix: As specified in Section 03300.

### 2.6 SOURCE QUALITY CONTROL AND TESTS

- A. General Requirements: Quality requirements for testing and inspection services.
- B. Submit proposed mix design of each type or class of concrete to appointed firm for review prior to commencement of Work.
- C. Tests on cement, aggregates and mixes will be performed to ensure conformance with specified requirements.
- D. Test samples in accordance with ACI 301.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for verification of existing conditions before starting work.
- B. Verify compacted substrate is acceptable and ready to support pavement.
- C. Verify gradients and elevations of base are correct.

### 3.2 PREPARATION

- A. Install vapor retarder to prevent absorption of water from fresh concrete.
- B. Coat surfaces of manhole and catch basin frames with oil to prevent bonding.
- C. Notify Engineer minimum 24 hours prior to commencement of concreting operations.

### 3.3 FORMING

- A. Place and secure forms to correct location, dimension, profile and gradient.
- B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.
- C. Place joint filler vertical in position, in straight lines. Secure to formwork during concrete placement.

### 3.4 REINFORCEMENT

- A. Place reinforcement as indicated; interrupt at contraction or expansion joints.
- B. Place additional dowels to achieve pavement and curb alignment.
- C. Provide doweled joints as necessary at transverse joints, interruptions of concrete, etc. for consideration and depending on frequency of traffic.

### 3.5 PLACING CONCRETE

- A. Coordinate installation of all embedded components.
- B. Place concrete in accordance with ACI 301, and as specified in Section 03300.
- C. Ensure reinforcement, inserts, embedded parts, and formed joints are not disturbed during concrete placement.
- D. Place concrete to pattern indicated.
- E. Place concrete continuously between predetermined compartments and construction joints. Do not break or interrupt successive pours such that cold joints occur.

### 3.6 JOINTS

- A. Place expansion or contraction joints at intervals indicated. Align curb, gutter and sidewalk joints.
- B. Place joint filler between paving components and other appurtenances. Recess top of filler 6 mm for sealant placement.
- C. Provide scored or sawn joints between sidewalks, curbs and pavement.
- D. Provide keyed joints where indicated.

### 3.7 EXPOSED AGGREGATE (IF REQUIRED)

- A. Apply surface retarder where exposed aggregate finish is required.
- B. Broadcast aggregate into plastic concrete, or sand blast concrete surfaces to achieve aggregate exposure indicated.
- C. Wash exposed aggregate surface with clean water and scrub with stiff bristle brush. Use of acid etch solution shall be to the approval of the Engineer.

### 3.8 FINISHING

- A. Texture finishing and direction of texturing shall be as specified in Section 03350, as shown on the drawings, and/or as directed by the Engineer.
- B. Place curing compound or sealer on exposed concrete surfaces immediately after finishing.

### 3.9 JOINT SEALING

- A. Separate pavement between compartments and from vertical or adjacent surfaces with 20 mm thick joint filler.
- B. Place joint filler from bottom to finished surface of pavement; in pavement pattern placement sequence; set top to required elevations; secure to resist movement by wet concrete.
- C. Conform to manufacturer's recommendations for finish joint sealer requirements.

### 3.10 TOLERANCES

- A. General Requirements: Quality requirements for tolerances.
- B. Maximum Variation of Surface Flatness: 6 mm in 3 m.
- C. Maximum Variation from True Position: 6 mm.

3.11 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Testing of concrete shall be as specified in Section 03300.

3.12 PROTECTION

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.
- B. Do not permit pedestrian and vehicular traffic over pavement for 7 days minimum after finishing and until 75 percent design strength of concrete has been achieved.

3.13 SCHEDULES

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

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:  

| <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,<br>(mm) | T (time),<br>(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.  
If pipe under test contains sections of various diameters, calculate allowable leakage from sum of computed leakage for each size.
      - f. If 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 quantity of leakage.
- 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 testing 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

## SECTION 02991

### UTILITY PERMANENT RELOCATION

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes investigation and location of existing services and utilities; and permanent relocation of existing services and utilities, and utility disconnection and reconnection.
- B. Related Sections:
  - 1. Section 02230 - Site Clearing.
  - 2. Section 02233 - Breaking Out and Reinstatement.
  - 3. Section 02315 - Excavation.
  - 4. Section 02320 - Backfill.
  - 5. Section 02324 - Trenching.
  - 6. Section 02513 - Water Distribution Systems.
  - 7. Section 02515 - Water Service Connections.
  - 8. Section 02536 - Pressure Sewer System (Force Mains).
  - 9. Section 02539 - Sanitary Sewer Systems.
  - 10. Section 02631 - Stormwater Drainage Systems.
  - 11. Section 02721 - Aggregate Sub-Base and Base Courses.
  - 12. Section 03300 - Cast-in-Place Concrete.
  - 13. Division 16 - Electrical: Permanent relocation of existing electrical and telephone items, and disconnection and re-connection of electric power and telephone networks.

##### 1.2 SUBMITTALS

- A. General Requirements: Requirements for submittals.
- B. Shop Drawings: Indicate types and locations of all existing utilities and services together with the protection details and the like.
- C. Existing Survey: Submit survey documents including written description and photographs to document existing conditions.

##### 1.3 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.
- B. Project Record Documents: Record actual locations of new utilities and services.

##### 1.4 QUALITY ASSURANCE

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

## 1.5 QUALIFICATIONS

- A. Design utility permanent relocation under direct supervision of approved Professional Engineer experienced in design of this Work and in full coordination with all relevant authorities and to the satisfaction of the Engineer.

## 1.6 PRE-RELOCATION MEETINGS

- A. General Requirements: Administrative requirements for pre-relocation meeting.
- B. Convene minimum one week before starting Work of this section.

## 1.7 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Sequence installation to ensure utility connections and reconnections are achieved in orderly and expeditious manner.
- C. Arrange schedule with Work of other sections.

# PART 2 PRODUCTS

## 2.1 UTILITY PERMANENT RELOCATION

- A. Definition of Utility: Any pipe, channel, culvert, duct, cable, pole, handhole, manhole, chamber, structure, etc. with related fittings, accessories and the like.
- B. Utility Products and Materials: To match existing, complying with relevant sections of these Specifications, in accordance with relevant authorities' standards, and to the satisfaction of the Engineer.
- C. Fill Materials: Types specified in Section 02320.
- D. Aggregate Materials: Types specified in Section 02721.

# PART 3 EXECUTION

## 3.1 INVESTIGATION AND LOCATION OF EXISTING SERVICES AND UTILITIES

- A. Investigate and locate existing services and utilities on, under and over the site, using electronic detection methods, hand digging, trial pits or any other approved means necessary.
- B. Identify utility services and obstructions to be removed, relocated or abandoned.
- C. Coordinate with all relevant authorities.
- D. Reinstate surfaces to match existing.

- E. Remove and dispose off resulting materials to approved dumping area.
- F. Prepare and submit to the Engineer for approval necessary "Shop Drawings" showing location of existing services and utilities, protection details, and the like.

### 3.2 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify availability and accessibility of access road to destination site.
- C. Obtain all necessary permits for work to be executed in destination site with any necessary access road construction thereto.

### 3.3 PREPARATION

- A. Design, construct to the satisfaction of the Engineer and remove upon completion of the works, any necessary access road to destination site.
- B. Prepare site and destination site.
- C. Take all necessary safety measures when relocating service utility.
- D. Coordinate Work of utility disconnection and reconnection with relevant authorities.
- E. Remove and replace upon completion of the work, overhead or exposed utility services for clear working space around utility.
- F. During relocation, protect adjacent private and public property from damage.

### 3.4 ORIGINAL SITE

- A. Break out existing paved or unpaved surfaces in accordance with Section 02233.
- B. Excavate in any type of soil and to any depth required, and dewater excavation of all water sources, all in accordance with Section 02315 and Section 02324.
- C. Protect existing utilities and provide all necessary temporary works to maintain utilities services in use during relocation works.
- D. Dismantle and remove disconnected utility.
- E. Carry out other works scheduled to be executed where the removed utility were encountered.
- F. Remove all temporary works and make good all disturbed surfaces.
- G. Backfill and compact to requirements of Section 02320 and Section 02324; place fill to elevations of original grades.
- H. Reinstate surfaces to match previously existing in accordance with Section 02233.

- I. Remove and dispose off resulting materials to approved dumping area.

### 3.5 DESTINATION SITE

- A. Break out existing paved or unpaved surfaces in accordance with Section 02233.
- B. Excavate in any type of soil and to any depth required, and dewater excavation of all water sources, all in accordance with Section 02315 and Section 02324.
- C. Supply and erection as per approved design and submitted shop drawings, of new utilities to match previously existing in accordance with these Specifications.
- D. Provide all necessary temporary works to carry out the work.
- E. Reconnect new work with existing utility services and test of completed relocated utility.
- F. Remove all temporary works and make good all disturbed surfaces.
- G. Backfill and compact to requirements of Section 02320 and Section 02324; place fill to elevations of original grades.
- H. Reinstate surfaces to match previously existing in accordance with Section 02233.
- I. Remove and dispose off resulting materials to approved dumping area.

### 3.6 SCHEDULE

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

END OF SECTION

## SECTION 03100

### CONCRETE FORMS AND ACCESSORIES

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section Includes:
  - 1. Formwork for cast-in place concrete.
  - 2. Shoring, bracing, and anchorage.
  - 3. Architectural form liners.
  - 4. Form accessories.
  - 5. Form stripping.
- B. Related Sections:
  - 1. Section 03200 - Concrete Reinforcement.
  - 2. Section 03300 - Cast-in-Place Concrete.
  - 3. Section 05500 - Metal Fabrications: Product requirements for metal fabrications for placement by this Section.

##### 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 mm or 200 mm in width, tongue and groove where explicitly shown on the 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 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. Screenshot Supports:
  - 1. For concrete over waterproof membranes and vapor barrier membranes, use cradle, pad or base type screed supports which will not puncture membrane.
  - 2. Staking through membrane is not permitted.
- P. Cleanouts and Access Panels:
  - 1. Provide removable cleanout sections or access panels at bottoms of forms to permit inspection and effective cleaning of dirt, debris and waste material.
  - 2. Clean forms and surfaces against which concrete is to be placed. Remove chips, saw dust and other debris. Thoroughly blow out forms with compressed air just before concrete is placed.

### 3.5 FORM CLEANING

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

### 3.6 FORM REMOVAL

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

### 3.7 ERECTION TOLERANCES

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

### 3.8 FIELD QUALITY CONTROL

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

### 3.9 SCHEDULES

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

END OF SECTION

## SECTION 03200

### CONCRETE REINFORCEMENT

#### PART 1 GENERAL

##### 1.1 SUMMARY

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

##### 1.2 REFERENCES

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

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

### 1.3 SUBMITTALS

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

### 1.4 QUALITY ASSURANCE

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

### 1.5 QUALIFICATIONS

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

### 1.6 COORDINATION

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

## PART 2 PRODUCTS

### 2.1 REINFORCEMENT

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

### 2.2 ACCESSORY MATERIALS

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

### 2.3 FABRICATION

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

## PART 3 EXECUTION

### 3.1 PLACEMENT

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

### 3.2 REINFORCEMENT TESTS

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

### 3.3 STORAGE OF MATERIALS

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

### 3.4 CUTTING AND BENDING

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

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

### 3.5 SPLICING AND WELDING

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

### 3.6 CLEANING OF REINFORCEMENT

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

### 3.7 FIXING OF REINFORCEMENT

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

### 3.8 PROJECTING REINFORCEMENT

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

### 3.9 FIELD QUALITY CONTROL

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

### 3.10 SCHEDULES

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

END OF SECTION

## SECTION 03300

### CAST-IN-PLACE CONCRETE

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes cast-in-place concrete for all concrete structures, frames, members, elements and beds shown on the drawings and where directed by the Engineer.
- B. Related Sections:
  - 1. Section 02320 - Backfill.
  - 2. Section 03100 - Concrete Forms and Accessories: Formwork and accessories for concrete and placement of construction joint device and anchors in forms.
  - 3. Section 03200 - Concrete Reinforcement.
  - 4. Section 07110 - Dampproofing.
  - 5. Section 07130 - Sheet Waterproofing.
  - 6. Section 07900 - Joint Sealers.
  - 7. Division 15 - Mechanical: Mechanical items for casting into concrete.
  - 8. Division 16 - Electrical: Electrical items for casting into concrete.

##### 1.2 REFERENCES

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

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

### 1.3 SUBMITTALS

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

### 1.4 CLOSEOUT SUBMITTALS

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

### 1.5 QUALITY ASSURANCE

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

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

#### 1.6 MOCKUP

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

#### 1.7 COORDINATION

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

#### 1.8 DELIVERY AND STORAGE OF AGGREGATES

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

### PART 2 PRODUCTS

#### 2.1 CEMENT

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

- B. White or colored cement shall comply with ASTM C150.
- C. The cement shall be obtained directly from an approved manufacturer or an approved supplier and shall be delivered either in bulk by purpose built vehicles or in sealed bags. All cement shall be free flowing and free of lumps.
- D. The total alkali content of the cement expressed as the sodium oxide equivalent shall not exceed 0.6% by weight.
- E. The tricalcium aluminates (C3A) content of ASTM C150 type I cement shall range from 7.5 to 11%, and for ASTM C150 type II and type V sulphate resisting cement shall not exceed 5%.
- F. The sulphuric anhydride (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 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 07110.

## 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: Concrete Forms and Accessories.
- F. Prefabricated Filling Materials: Type "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.
- J. Staifix Dowels: Stainless steel type 316, conforming to ASTM A276; minimum tensile strength 850 N/mm<sup>2</sup>; spaced at 400mm center to center; types as per drawings.

#### 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<br>C150<br>Cement         | Minimum Compressive<br>Strength at 28 days on |                | Maximum<br>Slump<br>(±20mm)<br>(mm) | Maximum<br>Water to<br>Cement<br>Ratio | Minimum<br>Cement<br>Content<br>(kg/m <sup>3</sup> ) | Notes                 |
|----------------------------------------------------------------------------------------|--------------------------------|-----------------------------------------------|----------------|-------------------------------------|----------------------------------------|------------------------------------------------------|-----------------------|
|                                                                                        |                                | cylinders<br>(MPa)                            | cubes<br>(MPa) |                                     |                                        |                                                      |                       |
| Blinding for foundation<br>beds and cyclopean<br>concrete.                             | Type II or V<br>(as indicated) | 14                                            | 18             | 180                                 | 0.60                                   | 250                                                  | Normal<br>weight Mix. |
| Reinforced concrete for<br>encasement & structures<br><u>not</u> in contact with sewer | Type I or II<br>(as indicated) | 30                                            | 38             | 180                                 | 0.42                                   | 350                                                  | Normal<br>weight Mix. |
| Reinforced concrete<br>works for manholes in<br>contact with sewer.                    | Type V                         | 35                                            | 44             | 180                                 | 0.40                                   | 375                                                  | Normal<br>weight Mix. |

- E. All concrete exposed surfaces shall have a fairfaced finish at no additional cost.
- F. Concrete with only fine aggregate (less than or equal to 9 mm) may be used for highly reinforced elements or for elements with small thicknesses.
- G. The concrete slump of the different types/classes of concrete shall be measured in accordance with 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  $\pm 2$  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  $5^{\circ}\text{C}$  and not more than  $28^{\circ}\text{C}$  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 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 the mixer be interrupted the vibrators should be lifted clear from the work.

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

### 3.12 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 to manufacturer's requirements.
  - 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 minimum.

### 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 shall be installed in accordance with 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 07110.
- 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. One filled the level is to be recorded at daily intervals for a period of fourteen days or as otherwise directed by the Engineer. Measures shall be taken by the Contractor to ensure that the level of water is not affected by rainfall or undue evaporation.
- C. Should it be apparent from the test results, external inspection or any other source that leakage/damp penetration has occurred, then, remedial work to make the construction completely watertight shall be carried out at the Contractor's expense and to the approval of the Engineer. Construction shall be retested until results are satisfactory.

### 3.18 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

## SECTION 05500

### METAL FABRICATIONS

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes shop fabricated metal items.
- B. Related Sections:
  - 1. Section 03300 - Cast-In-Place Concrete.
  - 2. Section 09900 - Paints and Coatings.
  - 3. Division 15 - Mechanical.

##### 1.2 REFERENCES

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

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

### 1.3 SUBMITTALS

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

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

#### 1.4 QUALITY ASSURANCE

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

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

#### 1.5 QUALIFICATIONS

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

#### 1.6 DELIVERY, STORAGE AND HANDLING

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

#### 1.7 FIELD MEASUREMENTS

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

### PART 2 PRODUCTS

#### 2.1 MATERIALS - STEEL

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

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

## 2.2 MATERIALS - STAINLESS STEEL

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

## 2.3 MATERIALS - ALUMINUM

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

## 2.4 ISOLATING NON-CONDUCTIVE MATERIALS BETWEEN DISSIMILAR METALS

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

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

## 2.5 STRUCTURAL SUPPORTS

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

## 2.6 ANCHOR BOLTS

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

## 2.7 FABRICATION

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

## 2.8 FACTORY APPLIED FINISHES - STEEL

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

- F. Galvanized Non-structural Items: Galvanized after fabrication to ASTM A123. Furnish minimum 380 and/or 360 g/m<sup>2</sup> galvanized coating.
- G. Chrome Plating: ASTM B177, nickel-chromium alloy, satin and/or polished finish.

## 2.9 FACTORY APPLIED FINISHES - STAINLESS STEEL

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

## 2.10 FACTORY APPLIED FINISHES - ALUMINUM

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

## 2.11 FABRICATION TOLERANCES

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

# PART 3 EXECUTION

## 3.1 EXAMINATION

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

## 3.2 PREPARATION

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

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

### 3.3 INSTALLATION

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

- K. Install isolating non-conductive materials between dissimilar metals as per approved methodology.
- L. Setting Loose Plates:
  - 1. Clean concrete and masonry bearing surfaces of any bond-reducing materials, roughen to improve bond to surfaces. Clean bottom surface of bearing plates.
  - 2. Set loose leveling and bearing plates on wedges, or other adjustable devices. After the bearing members have been positioned and plumbed, tighten the anchor bolts. Do not remove wedges or shims, but if protruding, cut off flush with the edge of the bearing plate before packing with grout.
  - 3. Pack grout solidly between bearing surfaces and plates to ensure that no voids remain.
- M. Butt welds or splice butt joints in track. Splices in axial loaded studs shall not be permitted. Welds shall be fillet, plug, butt, or seam.
  - 1. Secure floor and ceiling runners to structure with power driven anchors spaced not over 400mm on center and 150mm maximum from ends. Closer spacing at discretion of stud manufacturer based on design loads.
  - 2. Provide elastomeric sealant or sill sealer material between concrete structure and ceiling and floor runner channels at exterior.
- N. Slide Clip Detail: Provide flexible connection between studs and building structure to accommodate slab edge deflection and long term building creep without transferring axial load to studs.
- O. Tolerance: Wall construction to a maximum variation from plumb, level, or true-to-line of 3mm in 3m.
- P. Obtain approval of the Engineer prior to site cutting or making adjustments not scheduled.
- Q. After erection, touch up welds, abrasions, and damaged finishes with prime paint or galvanizing repair paint to match shop finishes.

### 3.4 ERECTION TOLERANCES

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

### 3.5 CLEANING

- A. General Requirements: Execution requirements for final cleaning.
- B. Remove site cuttings from finish surfaces.

- C. Clean and wash prefinished surfaces with mild soap and water; rinse with clean water.

### 3.6 SCHEDULES

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

END OF SECTION

## SECTION 07110

### DAMPPROOFING

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes hot or cold applied asphalt bituminous dampproofing, or hot applied coal tar bituminous dampproofing, applied in single or multiple coats; drainage panels and protective cover.
- B. Related Sections:
  - 1. Section 02320 - Backfill.
  - 2. Section 07212 - Board Insulation: Perimeter and horizontal protective covers.

##### 1.2 REFERENCES

- A. ASTM International:
  - 1. ASTM D41 - Standard Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing.
  - 2. ASTM D43 - Standard Specification for Coal Tar Primer Used in Roofing, Dampproofing, and Waterproofing.
  - 3. ASTM D449 - Standard Specification for Asphalt Used in Dampproofing and Waterproofing.
  - 4. ASTM D450 - Standard Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing.
  - 5. ASTM D1227 - Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.
  - 6. ASTM D3747 - Standard Specification for Emulsified Asphalt Adhesive for Adhering Roof Insulation.
  - 7. ASTM D4586 - Asphalt Roof Cement, Asbestos-Free.
  - 8. ASTM D5643 - Coal Tar Roof Cement, Asbestos Free.
- B. National Roofing Contractors Association:
  - 1. NRCA - The NRCA Waterproofing and Dampproofing Manual.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit properties of primer, bitumen, and mastics.
- C. Manufacturer's Installation Instructions: Submit special procedures and perimeter conditions requiring special attention.

##### 1.4 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product Requirements.
- B. Maintain ambient temperatures above 5°C during and for 24 hours after application.

## PART 2 PRODUCTS

### 2.1 BITUMINOUS DAMPPROOFING

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

### 2.2 COMPONENTS

- A. Hot Asphaltic Materials:
  - 1. Asphalt: ASTM D449, Type I, II, or III.
  - 2. Asphalt Primer: ASTM D41, compatible with substrate.
  - 3. Asphaltic Sealing Mastic: ASTM D4586 Type I, or II.
- B. Coal Tar Materials:
  - 1. Coal Tar: ASTM D450, Type II.
  - 2. Coal Tar Primer: ASTM D43, coal tar type.
  - 3. Coal Tar Sealing Mastic: ASTM D5643, bitumen filled with mineral dust and mineral fibers, to mastic consistency, without asbestos.
- C. Cold Asphaltic Materials:
  - 1. Asphalt emulsion to ASTM D3747, or emulsified asphalt to ASTM D1227, unreinforced, or reinforced with non-asbestos fibers.
  - 2. Asphalt Primer: ASTM D41, compatible with substrate.

### 2.3 ACCESSORIES

- A. Protection Board: 5 mm thick biodegradable hardboard, polystyrene foam sheet, asphalt wood fiberboard, or bitumen impregnated glass fiberboard, in accordance with Section 07212.
- B. Drainage Panel: 6 mm thick formed plastic or molded flexible rubber, hollowed sandwich or embossed with cover sheet.
- C. Flexible Flashings: Compatible with bitumen type, butyl or EPDM.

## 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 dampproofing system.
- C. Verify items penetrating surfaces to receive dampproofing are securely installed.

### 3.2 PREPARATION

- A. Protect adjacent surfaces not designated to receive dampproofing.
- B. Clean and prepare surfaces to receive dampproofing.
- C. Do not apply dampproofing to surfaces unacceptable to manufacturer.
- D. Apply mastic to seal penetrations, small cracks, or minor honeycomb in substrate.

### 3.3 INSTALLATION

- A. Prime surfaces in accordance with NRCA - Waterproofing Manual. Prime surfaces at rate recommended by the manufacturer to suit application. Permit primer to dry.
- B. Apply hot or cold bitumen with mop or roller, or by spray application, or by trowel.
- C. For hot applied bitumen, apply at temperature limited by equiviscous temperature (EVT) plus or minus 14°C; do not exceed finish blowing temperature for four hours.
- D. Apply bitumen in two coats, continuous and uniform, at rate recommended by the manufacturer to suit application.
- E. Apply from 50 mm below finish grade elevation. Cover all surfaces in contact with soil.
- F. Seal items projecting through dampproofing surface with mastic. Seal watertight.
- G. Place drainage panel directly against membrane, butt joints, place to encourage drainage downward.
- H. Place protection board directly against drainage panel and membrane; butt joints.
- I. Adhere protection board and drainage panel to substrate with mastic. Scribe and cut boards around projections, penetrations and interruptions.
- J. Immediately backfill against dampproofing to protect from damage.
- K. Install Work as specified, as shown on the drawings, in accordance with the manufacturer's recommendations, and to the satisfaction of the Engineer.

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

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

### 2.3 ACCESSORIES

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

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

## PART 3 EXECUTION

### 3.1 EXAMINATION

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

### 3.2 PREPARATION

- A. Protect adjacent surfaces not designated to receive waterproofing.
- B. Clean and prepare surfaces to receive waterproofing.
- C. Execute cement sand mortar at all intersections to make beveled corners (fillet) of size 50 x 50 mm.
- 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 150 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.

### 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 150 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 150 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 surface dusting and/or protective covering.
- B. Related Sections:
  - 1. Section 02320 - Backfill.
  - 2. Section 07212 - Board Insulation: Perimeter and horizontal insulation protective cover.
  - 3. Section 07620 - Sheet Metal Flashing and Trim.
  - 4. Section 07900 - Joint Sealers.
  - 5. Division 15 - Mechanical: Plumbing fixtures and plumbing specialties.

##### 1.2 REFERENCES

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

### 1.3 SYSTEM DESCRIPTION

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

### 1.4 SUBMITTALS

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

### 1.5 QUALITY ASSURANCE

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

### 1.6 QUALIFICATIONS

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

### 1.7 MOCKUP

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

## 1.8 PRE-INSTALLATION MEETINGS

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

## 1.9 ENVIRONMENTAL REQUIREMENTS

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

## 1.10 WARRANTY

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

# PART 2 PRODUCTS

## 2.1 FLUID APPLIED WATERPROOFING

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

## 2.2 COMPONENTS

- A. Waterproofing Membrane: Fluid; 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 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: Rigid insulation 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. Clean and prepare surfaces to receive waterproofing.
- C. Do not apply waterproofing to surfaces unacceptable to manufacturer.
- D. Seal cracks and joints with sealant materials using depth to width ratio as recommended by sealant manufacturer and/or in accordance with Section 07900.

### 3.3 INSTALLATION

- A. Apply surface conditioner at rate recommended by manufacturer. Protect conditioner from rain or frost until dry.
- B. 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.
- C. At expansion joints from 13 to 25 mm in width, loop cover sheet down into joint between 31 and 44 mm. Extend sheet 150 mm on both sides of expansion joint.
- D. 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 150 mm beyond sheet edges. Apply this procedure especially to expansion joints between horizontal and vertical surfaces.
- E. Apply waterproofing material.
- F. Apply and spread waterproofing material to a minimum cured thickness and averaging thickness as recommended by the manufacturer.
- G. Extend membrane over cants and up intersecting surfaces at membrane perimeter minimum 150 mm above horizontal surface.
- H. Install cant strips at inside corners.
- I. Apply extra thickness of waterproofing material at corners, intersections, angles, and over joints.
- J. Seal items protruding to or penetrating through membrane and install counter-flashing membrane material.
- K. 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.
- L. Install membrane flashings and seal into waterproofing material.
- M. Conform to NRCA - Waterproofing Manual drawing details as noted:
- N. Place drainage panel directly against membrane, butt joints, place to encourage drainage downward.
- O. Place protection board and/or panel directly against drainage panel and/or membrane; butt joints.
- P. Adhere protection board and/or drainage panel to substrate with mastic. Scribe and cut boards around projections, penetrations, and interruptions.
- Q. Install Work in accordance with the drawings, to the manufacturer's instructions and to the approval of the Engineer.

### 3.4 FIELD QUALITY CONTROL

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

### 3.5 PROTECTION OF INSTALLED CONSTRUCTION

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

### 3.6 SCHEDULES

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

END OF SECTION

## SECTION 07212

### BOARD INSULATION

#### PART 1 GENERAL

##### 1.1 SUMMARY

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

##### 1.2 REFERENCES

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

##### 1.3 SYSTEM DESCRIPTION

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

#### 1.4 SUBMITTALS

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

#### 1.5 ENVIRONMENTAL REQUIREMENTS

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

#### 1.6 SEQUENCING

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

#### 1.7 COORDINATION

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

### PART 2 PRODUCTS

#### 2.1 BOARD INSULATION

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

#### 2.2 COMPONENTS

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

## 2.3 ACCESSORIES

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

## PART 3 EXECUTION

### 3.1 EXAMINATION

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

### 3.2 INSTALLATION

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

### 3.3 PROTECTION OF INSTALLED CONSTRUCTION

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

### 3.4 SCHEDULES

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

END OF SECTION

## SECTION 07260

### VAPOR RETARDERS

#### PART 1 GENERAL

##### 1.1 SUMMARY

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

##### 1.2 REFERENCES

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

##### 1.3 PERFORMANCE REQUIREMENTS

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

##### 1.4 SUBMITTALS

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

##### 1.5 QUALITY ASSURANCE

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

##### 1.6 MOCKUP

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

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

## 1.7 SEQUENCING

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

## PART 2 PRODUCTS

### 2.1 VAPOR RETARDERS

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

### 2.2 COMPONENTS

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

### 2.3 ACCESSORIES

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

### PART 3 EXECUTION

#### 3.1 PREPARATION

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

#### 3.2 EXISTING WORK

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

#### 3.3 INSTALLATION

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

#### 3.4 SCHEDULES

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

END OF SECTION

## SECTION 07270

### AIR BARRIERS

#### PART 1 GENERAL

##### 1.1 SUMMARY

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

##### 1.2 REFERENCES

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

##### 1.3 DEFINITIONS

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

##### 1.4 DESIGN REQUIREMENTS

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

## 1.5 PERFORMANCE REQUIREMENTS

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

## 1.6 SUBMITTALS

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

## 1.7 QUALITY ASSURANCE

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

## 1.8 MOCKUP

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

## 1.9 PRE-INSTALLATION MEETINGS

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

## 1.10 ENVIRONMENTAL REQUIREMENTS

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

## 1.11 SEQUENCING

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

## 1.12 COORDINATION

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

# PART 2 PRODUCTS

## 2.1 AIR BARRIERS

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

## 2.2 COMPONENTS

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

## 2.3 ACCESSORIES

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

## PART 3 EXECUTION

### 3.1 PREPARATION

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

### 3.2 INSTALLATION

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

### 3.3 PROTECTION OF INSTALLED CONSTRUCTION

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

### 3.4 SCHEDULES

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

END OF SECTION

## SECTION 07620

### SHEET METAL FLASHING AND TRIM

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes flashings and counterflashings, sheet metal roofing and fabricated sheet metal items, as indicated in Schedule.
  - 1. Provide reglets and accessories, precast concrete splash pads, and/or sheet metal splash pans.
- B. Related Sections:
  - 1. Section 03100 - Concrete Forms and Accessories: Placement of recessed flashing reglets and accessories.
  - 2. Section 04810 - Unit Masonry Assemblies: Through-wall flashings in masonry.
  - 3. Section 07900 - Joint Sealers.
  - 4. Section 09900 - Paints and Coatings: Field painting.
  - 5. Division 15 - Mechanical: Hangers and Supports.

##### 1.2 REFERENCES

- A. American Architectural Manufacturers Association:
  - 1. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum.
  - 2. AAMA 2603 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels.
  - 3. AAMA 2604 - Voluntary specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels.
  - 4. AAMA 2605 - Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
- B. ASTM International:
  - 1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  - 2. ASTM A666 - Standard Specification for Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
  - 3. ASTM A924/A924M - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
  - 4. ASTM B32 - Standard Specification for Solder Metal.
  - 5. ASTM B101 - Standard Specification for Lead-Coated Copper Sheet and Strip for Building Construction.
  - 6. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
  - 7. ASTM B370 - Standard Specification for Copper Sheet and Strip for Building Construction.

8. ASTM B749 - Standard Specification for Lead and Lead Alloy Strip, Sheet, and Plate Products.
  9. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
  10. ASTM D4397 - Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications.
  11. ASTM D4586 - Standard Specification for Asphalt Roof Cement, Asbestos-Free.
- C. Copper Development Association Inc.:
1. CDA - Copper in Architecture - Handbook.
- D. Federal Specification Unit:
1. FS TT-C-494 - Coating Compound, Bituminous, Solvent Type, Acid Resistant.
- E. Sheet Metal and Air Conditioning Contractors:
1. SMACNA - Architectural Sheet Metal Manual.

### 1.3 DESIGN REQUIREMENTS

- A. Sheet Metal Flashings: Conform to the criteria of SMACNA "Architectural Sheet Metal Manual" and/or Copper Development Association "Copper in Architecture - Handbook".
- B. Gutter and Downspout Components: Conform to SMACNA Manual, CDA Handbook, SSINA Standard Practice, and/or NRCA Details for sizing components for rainfall intensity determined by storm occurrence of 1 in 5 years.
- C. Maintain one copy of each document on site.

### 1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Shop Drawings: Indicate material profile, jointing pattern, jointing details, fastening methods, flashings, terminations, and installation details.
- C. Product Data: Submit data on manufactured components metal types, finishes, and characteristics.
- D. Samples:
  1. Submit two samples, size as directed by the Engineer, illustrating seam, external and/or internal corners, valley, ridge, junction to vertical dissimilar surface, material and finish.

### 1.5 QUALIFICATIONS

- A. Fabricator and Installer: Company specializing in sheet metal work with minimum ten years documented experience.

## 1.6 PRE-INSTALLATION MEETINGS

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

## 1.7 DELIVERY, STORAGE AND HANDLING

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

## 1.8 COORDINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Coordinate with Work of Section 03100 and Section 04810 for installing recessed flashing reglets.

# PART 2 PRODUCTS

## 2.1 SHEET METAL FLASHING AND TRIM

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. Aluminum Sheet: ASTM B209M, alloy and temper as required for application and finish; 0.8 mm thick; finish and color as selected by the Engineer.

## 2.2 ACCESSORIES

- A. Fasteners: Same material and finish as flashing metal.
- B. Underlayment: ASTM D4397, 0.25 mm polyethylene.
- C. Slip Sheet: As recommended by manufacturer.
- D. Primer: As recommended by manufacturer.
- E. Protective Backing Paint: As recommended by manufacturer.
- F. Sealant: Type as specified in Section 07900.
- G. Plastic Cement: ASTM D4586, Type I.
- H. Reglets: As recommended by manufacturer.

- I. Splash Pads: Precast concrete type, of sizes and profiles as indicated; minimum 29 MPa at 28 days, with minimum 5 percent air entrainment.
- J. Downspout Boots and/or Shoes: As recommended by manufacturer.
- K. Solder: ASTM B32; type suitable for application and material being soldered.

## 2.3 FABRICATION

- A. Form sections shape indicated on Drawings, accurate in size, square and free from distortion or defects.
- B. Fabricate cleats of same material as sheet metal, interlocking with sheet.
- C. Form pieces in single length sheets.
- D. Hem exposed edges on underside 13 mm; miter and seam corners.
- E. Form material with standing, batten and/or flat lock seams, except where otherwise indicated. At moving joints, use sealed lapped, bayonet-type or interlocking hooked seams.
- F. Tin edges of copper sheet to be soldered. Solder shop formed metal joints. After soldering, remove flux. Wipe and wash solder joints clean. Weather seal joints.
- G. Fabricate corners from one piece with minimum 450 mm long legs; seam and/or solder for rigidity, seal with sealant.
- H. Fabricate vertical faces with bottom edge formed outward 6 mm and hemmed to form drip.
- I. Fabricate flashings to allow toe to extend 50 mm over roofing gravel and/or paver. Return and brake edges.
- J. Fabricate guards as detailed on drawings.
- K. Fabricate gutters to profile and size indicated.
- L. Fabricate downspouts to profile and size indicated.
- M. Fabricate accessories in profile and size to suit gutters and downspouts.
  - 1. Anchorage Devices: Type recommended by fabricator.
  - 2. Gutter Supports: Type recommended by fabricator.
  - 3. Downspout Supports: Type recommended by fabricator.
- N. Fabricate splash pans of same metal type as downspouts, dimension as recommended by fabricator.
- O. Seal metal joints.

## 2.4 FACTORY FINISHING

- A. Factory Finish: as recommended by finish system manufacturer.
- B. Primer Coat: Finish concealed side of metal sheets with primer compatible with finish system, as recommended by finish system manufacturer.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify roof openings, curbs, pipes, sleeves, ducts, and vents through roof are solidly set, reglets in place, and nailing strips located.
- C. Verify roofing termination and base flashings are in place, sealed, and secure.

### 3.2 PREPARATION

- A. Install starter and edge strips, and cleats before starting installation.
- B. Install surface mounted reglets to lines and levels indicated on Drawings. Seal top of reglets with sealant.
- C. Paint concealed metal surfaces with protective backing paint to minimum dry film thickness of 0.4 mm.

### 3.3 INSTALLATION

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

### 3.4 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Inspection will involve surveillance of Work during installation to ascertain compliance with specified requirements.

### 3.5 SCHEDULES

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

END OF SECTION

## SECTION 07900

### JOINT SEALERS

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes sealants and joint backing, precompressed foam sealers, hollow gaskets and accessories.
- B. Related Sections:
  - 1. Section 03300 - Cast-in-Place Concrete.

##### 1.2 REFERENCES

- A. ASTM International:
  - 1. ASTM C834 - Standard Specification for Latex Sealants.
  - 2. ASTM C919 - Standard Practice for Use of Sealants in Acoustical Applications.
  - 3. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.
  - 4. ASTM C1193 - Standard Guide for Use of Joint Sealants.
  - 5. ASTM D1056 - Standard Specification for Flexible Cellular Materials- Sponge or Expanded Rubber.
  - 6. ASTM D1667 - Standard Specification for Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam).
  - 7. ASTM D2628 - Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements.

##### 1.3 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Products Data: Submit data indicating sealant chemical characteristics, performance criteria, substrate preparation, limitations, and color availability.
- C. Samples: Submit samples illustrating sealant colors for selection.
- D. Manufacturer's Installation Instructions: Submit special procedures, surface preparation, and perimeter conditions requiring special attention.
- E. Warranty: Include coverage for installed sealants and accessories failing to achieve airtight seal or watertight seal, exhibit loss of adhesion or cohesion, and sealants which do not cure.

##### 1.4 QUALITY ASSURANCE

- A. General Joint Sealer Performance Requirements: Select materials for compatibility with joint surfaces and other indicated exposures.
  - 1. Select modulus of elasticity and hardness or grade recommended by manufacturer for each application indicated.

2. Where exposed to foot traffic, select materials of sufficient strength and hardness to withstand stiletto heel traffic without damage or deterioration of sealer system.
- B. Color Selection: Provide colors indicated and if not, to match adjacent material or paint color; provide custom colors where required; colors to be selected by Engineer.
- C. Perform work in accordance with sealant manufacturers' requirements for preparation of surfaces and material installation instructions.
- D. Contractor shall require sealant manufacturer to review joint conditions and details, and shall submit to the Engineer written certification from the sealant manufacturer that joints are of the proper size and design, that the materials and backing will properly perform to provide permanent watertight, airtight or vaportight seals (as applicable), and that materials supplied meet specified performance requirements.
  1. Certification shall include copies of manufacturer's test regarding adhesion and staining of adjacent.
- E. Perform acoustical sealant application work in accordance with ASTM C919.
- F. Maintain one copy of each referenced document on site.

#### 1.5 QUALIFICATIONS

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

#### 1.6 MOCKUP

- A. General Requirements: Quality requirements for mockup.
- B. Construct mockup of sealant joints in conjunction with window, wall and other mockups specified in other sections.
- C. Construct mockup with specified sealant types and with other components noted.
  1. Determine preparation and priming requirements based on manufacturer's recommendations; take action necessary for correction of failure of sealant tests on mock-up.
  2. Verify sealants, primers and other components don't stain adjacent materials.
- D. Locate where directed by the Engineer.
- E. Remove mockup when directed by the Engineer.

#### 1.7 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Products requirements.

- B. Maintain temperature and humidity recommended by sealant manufacturer during and after installation.

## 1.8 COORDINATION

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

## PART 2 PRODUCTS

### 2.1 JOINT SEALERS

- A. Manufacturer: Any internationally recognized manufacturer having an official technical agreement to conformity with standards for the product.
- B. General:
  - 1. Provide a complete system of cleaners, primers, fillers, tapes, backer rods and tapes and sealants in accordance with the manufacturer's requirements and the standards specified herein.
  - 2. Color of Sealants:
    - a. For Concealed Joints: Provide the manufacturer's standard color which has the best overall performance quantities for the application shown.
    - b. For Exposed Joints: Provide custom colors as selected by the Engineer from the manufacturer's standard colors or other special custom colors.
- C. 2-Part Polyurethane Sealant: Polyurethane based 2-part elastomeric sealant, in accordance and complying with Fed. Spec. TT-S-00227, Type II, Class A, with elongation and compression of not less than 25 %; ASTM C920, Type M, Class 25, Grade NS.
  - 1. Location: Exterior joints within masonry and concrete.
  - 2. Acceptable Manufacturers and Product:
    - a. Tremco: Dymeric.
    - b. Sonneborn Building Products: Sonolastic NP II.
- D. Medium Modulus Silicone Rubber Sealant: Silicone rubber based 1-part neutral cure elastomeric sealant with plus 50 percent to minus 50 percent movement complying with ASTM C920 and Fed. Spec. TT-S-001543, Class A, and recommended by manufacturer for joints.
  - 1. Location: Exterior joints subject to movement, NOT in contact with external insulation finishing system (EIFS).
  - 2. Acceptable Manufacturers and Product:
    - a. Dow Corning Corporation: 795 Building Sealant or DC 791.
    - b. Sonneborn, ChemRex Inc.: Sonolastic Omniseal or OmniPlus.
    - c. Tremco Construction Division: Spectrum 2.

- E. Foam Gasket Seal: Precompressed, impregnated open-cell foam sealant incorporating permanently elastic open cell polyurethane foam, manufacturer's standard impregnating agent, and pressure sensitive backing.
  - 1. Acceptable Manufacturers and Product:
    - a. Emseal Corporation: Emseal Greyflex.
    - b. Illbruck Inc.: Will-Seal 150.
    - c. York Manufacturing, Inc.: York-Seal 100.
- F. Foam Gasket Seal for Submerged Application: Precompressed, impregnated open-cell foam sealant incorporating permanently elastic open cell polyurethane foam, manufacturer's impregnating agent at higher levels than standard product, and pressure sensitive backing.
  - 1. Specially designed for use in submerge application.
  - 2. Acceptable Manufacturers and Product:
    - a. Emseal Corporation: Emseal.
    - b. Illbruck Inc.: Will-Seal 200.
    - c. York Manufacturing, Inc.: York-Seal 200.
- G. Splice Adhesive for Foam Gasket Seal: 1-part urethane wet sealant as recommended by gasket seal manufacturer.

## 2.2 ACCESSORIES

- A. Primer: Non-staining type, recommended by sealant manufacturer to suit application.
- B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.
- C. Joint Backing: Round foam rod compatible with sealant; ASTM D1056, sponge or expanded rubber; or ASTM D1667, closed cell PVC; oversized 30 to 50 % larger than joint width.
  - 1. Type: As recommended by manufacturer.
- D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer.

## PART 3 EXECUTION

### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify substrate surfaces and joint openings are ready to receive work.
- C. Verify joint backing and release tapes are compatible with sealant.

### 3.2 PREPARATION

- A. Remove loose materials and foreign matter impairing adhesion of sealant.
- B. Clean and prime joints.

- C. Perform preparation in accordance with ASTM C1193.
- D. Protect elements surrounding Work of this section from damage or disfiguration.

### 3.3 INSTALLATION

- A. Perform installation in accordance with ASTM C1193.
- B. Perform acoustical sealant application work in accordance with ASTM C919.
- C. Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer, except where specific dimensions are indicated.
- D. Install bond breaker where joint backing is not used.
- E. Install sealant free of air pockets, foreign embedded matter, ridges, and sags.
- F. Apply sealant within recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.
- G. Tool joints as detailed.
- H. Precompressed Foam Sealant: Do not stretch; avoid joints except at corners, ends, and intersections; install with face 3 to 6 mm below adjoining surface.
- I. Compression Gaskets: Avoid joints except at ends, corners, and intersections; seal joints with adhesive; install with face 3 to 6 mm below adjoining surface.

### 3.4 CLEANING

- A. General Requirements: Execution requirements for final cleaning.
- B. Clean adjacent soiled surfaces.

### 3.5 PROTECTION OF INSTALLED CONSTRUCTION

- A. General Requirements: Execution requirements for protecting installed construction.
- B. Protect sealants until cured.

### 3.6 SCHEDULES

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

END OF SECTION

## SECTION 09900

### PAINTS AND COATINGS

#### PART 1 GENERAL

##### 1.1 SUMMARY

- A. Section includes surface preparation and field application of paints, stains, varnishes, and other coatings.
- B. Related Sections:
  - 1. Division 5 - Metals: Shop primed metal items.
  - 2. Division 15 - Mechanical: Mechanical Identification.
  - 3. Division 16 - Electrical: Electrical Identification.

##### 1.2 REFERENCES

- A. ASTM International:
  - 1. ASTM D16 - Standard Terminology Relating to Paint, Varnish, Lacquer, and Related Products.
  - 2. ASTM D4442 - Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials.
- B. Painting and Decorating Contractors of America:
  - 1. PDCA - Architectural Painting Specification Manual.
- C. SSPC: The Society for Protective Coatings:
  - 1. SSPC - Steel Structures Painting Manual.

##### 1.3 DEFINITIONS

- A. Conform to ASTM D16 for interpretation of terms used in this section.

##### 1.4 SUBMITTALS

- A. General Requirements: Requirements for submittal procedures.
- B. Product Data: Submit data on finishing products and special coating.
- C. Samples:
  - 1. Submit two paper chip samples each 300 x 300 mm, illustrating color range and textures available for each surface finishing product scheduled.
  - 2. Submit two painted samples, illustrating selected colors and textures for each color and system selected with specified coats cascaded.
- D. Manufacturer's Installation Instructions: Submit special surface preparation procedures, and substrate conditions requiring special attention.

## 1.5 CLOSEOUT SUBMITTALS

- A. General Requirements: Execution requirements for closeout procedures.
- B. Operation and Maintenance Data: Submit data on cleaning, touch-up, and repair of painted and coated surfaces.

## 1.6 QUALIFICATIONS

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

## 1.7 MOCKUP

- A. General Requirements: Quality requirements for mock-up.
- B. Construct mockup panel, size as directed by the Engineer, illustrating special coating color, texture, and finish.
- C. Construct door and frame assembly illustrating painting, stain and varnish, coating color, texture, and finish.
- D. Locate where directed by the Engineer.
- E. Remove mockup when directed by the Engineer.

## 1.8 PRE-INSTALLATION MEETINGS

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

## 1.9 DELIVERY, STORAGE AND HANDLING

- A. General Requirements: Product requirements for product storage and handling.
- B. Deliver products to site in sealed and labeled containers; inspect to verify acceptability.
- C. Container Label: Include manufacturer's name, type of paint, brand name, lot number, brand code, coverage, surface preparation, drying time, cleanup requirements, color designation, and instructions for mixing and reducing.
- D. Storage of Paint Materials: Store at minimum ambient temperature of 7°C and maximum ambient temperature of 32°C in ventilated area, and as required by manufacturer's instructions.

## 1.10 ENVIRONMENTAL REQUIREMENTS

- A. General Requirements: Product requirements.
- B. Do not apply materials when surface and ambient temperatures are outside temperature ranges required by paint product manufacturer.
- C. Do not apply exterior coatings during rain/snow, or when relative humidity or moisture content of surfaces exceed those required by paint product manufacturer.
- D. Minimum Application Temperatures for Latex Paints: 7°C for interiors; 10°C for exterior, unless required otherwise by manufacturer's instructions.
- E. Minimum Application Temperature for Varnish Finishes: 18°C for interior or exterior, unless required otherwise by manufacturer's instructions.
- F. Provide lighting level of 860 lx measured mid-height at substrate surface.

## 1.11 SEQUENCING

- A. General Requirements: Requirements for Work sequence.
- B. Sequence application to the following:
  - 1. Do not apply finish coats until paintable sealant is applied.
  - 2. Back prime wood trim before installation of trim.

## 1.12 WARRANTY

- A. General Requirements: Execution requirements for product warranties and bonds.
- B. Furnish five year manufacturer warranty for paints and coatings.

## 1.13 EXTRA MATERIALS

- A. General Requirements: Execution requirements for spare parts and maintenance products.
- B. Supply 4 liters of each color, type and surface texture; store where directed.
- C. Label each container with color, type, texture and room locations in addition to manufacturer's label.

# PART 2 PRODUCTS

## 2.1 MANUFACTURER

- A. Paint, Transparent Finishes, Stain, Primer Sealers, Block Filler, and Field Catalyzed Coatings Manufacturers: Any internationally recognized manufacturers having an official technical agreement to conformity with standards for the products.
- B. Furnish materials as specified, as shown on drawings and to Engineer's satisfaction.

## 2.2 COMPONENTS

- A. Coatings: Ready mixed, except field catalyzed coatings. Process pigments to a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating; prepare coatings for good flow and brushing properties, capable of drying or curing, and free of streaks or sags.
- B. Use products of the same manufacturer for succeeding coats. Where primer is shop applied to steel, subsequent coats may be the product of another manufacturer provided the coatings are mutually compatible.
- C. Colors, textures and degree of luster shall be as selected by the Engineer. Tint prime and undercoats approximately to the shade of the final coat but with sufficient variation to distinguish them from the preceding coat. Proprietary names used to designate colors or materials, are not intended to imply that products named are required, or to exclude equal products of other manufacturers.
- D. Colors of finishes shall not necessarily be manufacturer's stock colors. All materials for finishing coats shall be factory mixed and shall be of a standard quality equal to that of the standard colors of the material specified.
- E. Specular Gloss Range:
1. Ranges determined in accordance with ASTM D523:

| <u>Sheen</u> | <u>Geometry / Degree</u> | <u>Gloss / Range</u> |
|--------------|--------------------------|----------------------|
| Flat         | 85                       | Below 15             |
| Eggshell     | 60                       | 5 to 20              |
| Semi-Gloss   | 60                       | 30 to 65             |
| Gloss        | 60                       | Over 65              |
  2. In locations where ambient temperature and humidity conditions encourage the ready formation of mildew, use paints with additional mildew inhibitive agent incorporate during the manufacturing process, of type and in concentration recommended by the paint manufacturer to withstand such mildew formation.
- F. Accessory Materials: Linseed oil, shellac, turpentine, paint thinners and other materials not specifically indicated but required to achieve the finishes specified.
- G. Patching Materials: Latex filler.
- H. Fastener Head Cover Materials: Latex filler.

## 2.3 HIGH-PERFORMANCE COATINGS COMPONENTS

- A. General: Furnish complete multi-coat systems formulated and recommended by manufacturer for applications indicated, in thicknesses indicated; number of coats specified does not include primer or filler coat.
1. Lead content: None.
  2. Chromium content, as zinc chromate or strontium chromate: None.
  3. Maximum VOC content: As required by applicable regulations.
  4. Colors: As selected from manufacturer's standard colors or as per Drawings.

- B. Epoxy Coating: Two coats; polyamide, or polyester epoxy; complying with MIL C-22750; gloss, semi-gloss, or eggshell finish.
  - 1. Percentage of solids by volume: To manufacturer's recommendations to suit project requirements.
  - 2. Dry film thickness per coat: 150 microns minimum, unless otherwise shown on drawings.
  - 3. Comply with performance requirements of MIL C-22750
- C. Epoxy Floor Coating: Two coats, two-part, polyamide or polyester epoxy, non-skid.
  - 1. Percentage of solids by volume: To manufacturer's recommendations to suit project requirements.
  - 2. Dry film thickness per coat: 200 microns minimum including aggregates, unless otherwise shown on drawings.
  - 3. Comply with performance requirements of MIL C-22750.
- D. Primers: As recommended by coating manufacturer for specific substrate with a minimum of 50 microns dry film thickness.
- E. Shellac: Pure, white type.

#### 2.4 FIBER REINFORCED EPOXY COATING/LINING FOR SEWER STRUCTURES

- A. One layer of approved coal tar pitch epoxy coating, 200 microns thick, as per manufacturer's instructions.
- B. One layer of approved fiberglass mesh-reinforcement as per manufacturer's instructions, thickness ranging from 3 to 4 mm.
- C. Another two layers of the approved coal tar pitch epoxy coating, 200 microns thick each, as per manufacturer's instructions.
- D. One approved plastic panel facing (if shown on drawings) as per manufacturer's instructions, thickness ranging from 2 to 3 mm.

### PART 3 EXECUTION

#### 3.1 EXAMINATION

- A. General Requirements: Administrative requirements for coordination and project conditions.
- B. Verify surfaces and substrate conditions are ready to receive Work as instructed by product manufacturer.
- C. Examine surfaces scheduled to be finished prior to commencement of work. Report conditions capable of affecting proper application.
- D. Test shop applied primer for compatibility with subsequent cover materials.

- E. Measure moisture content of surfaces using electronic moisture meter. Do not apply finishes unless moisture content of surfaces are below the following values:
  - 1. Plaster and Gypsum Boards: 12 percent.
  - 2. Masonry, Concrete and Concrete Unit Masonry: 12 percent.
  - 3. Wood: 15 percent, measured in accordance with ASTM D 4442.
  - 4. Concrete Floors: 8 percent.

### 3.2 PREPARATION

- A. Surface Appurtenances: Remove or mask electrical plates, hardware, light fixture trim, escutcheons, and fittings prior to preparing surfaces or finishing.
- B. Surfaces: Correct defects and clean surfaces capable of affecting work of this section. Remove or repair existing coatings exhibiting surface defects.
- C. Marks: Seal with shellac those which may bleed through surface finishes.
- D. Impervious Surfaces: Remove mildew by scrubbing with solution of tetra-sodium or tri-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.
- E. Aluminum Surfaces Scheduled for Paint Finish: Remove surface contamination by steam or high pressure water. Remove oxidation with acid etch and solvent washing. Apply etching primer immediately following cleaning.
- F. Asphalt, Creosote, or Bituminous Surfaces Scheduled for Paint Finish: Remove foreign particles to permit adhesion of finishing materials. Apply latex based, or compatible sealer or primer.
- G. Insulated Coverings: Remove dirt, grease, and oil from canvas and cotton.
- H. Concrete Floors: Remove contaminations, acid etch and rinse floors with clear water. Verify required acid-alkali balance is achieved. Allow to dry.
- I. Copper Surfaces Scheduled for Natural Oxidized Finish: Remove contamination by applying oxidizing solution of copper acetate and ammonium chloride in acetic acid. Rub on repeatedly for required effect. Once attained, rinse surfaces with clear water and allow to dry.
- J. Copper Surfaces Scheduled for Paint Finish: Remove contamination by steam, high pressure water, or solvent washing. Clean and immediately apply vinyl etch primer.
- K. Gypsum Board Surfaces: Fill minor defects with filler compound. Spot prime defects after repair.
- L. Galvanized Surfaces: Remove surface contamination and oils and wash with solvent. Apply coat of etching primer.
- M. Concrete and Unit Masonry Surfaces Scheduled to Receive Paint Finish: Remove dirt, loose mortar, scale, salt or alkali powder, and other foreign matter. Remove oil and grease with solution of tri-sodium phosphate; rinse well and allow to dry. Remove stains caused by weathering of corroding metals with solution of sodium meta-silicate after thoroughly wetting with water. Allow for drying.

- N. Plaster Surfaces: Fill hairline cracks, small holes, and imperfections with latex patching plaster. Make smooth and flush with adjacent surfaces. Wash and neutralize high alkali surfaces.
- O. Uncoated Steel and Iron Surfaces: Remove grease, mill scale, weld splatter, dirt, and rust. Where heavy coatings of scale are evident, remove by hand or power tool wire brushing or sandblasting; clean by washing with solvent. Apply treatment of phosphoric acid solution, ensuring weld joints, bolts, and nuts are similarly cleaned. Spot prime paint after repairs.
- P. Shop Primed Steel Surfaces: Sand and scrape to remove loose primer and rust. Feather edges to make touch-up patches inconspicuous. Clean surfaces with solvent. Prime bare steel surfaces. Prime metal items including shop primed items.
- Q. Interior Wood Items Scheduled to Receive Paint Finish: Wipe off dust and grit prior to priming. Seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after primer has dried; sand between coats.
- R. Interior Wood Items Scheduled to Receive Transparent Finish: Wipe off dust and grit prior to sealing, seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes and cracks after sealer has dried; sand lightly between coats.
- S. Exterior Wood Scheduled to Receive Paint Finish: Remove dust, grit, and foreign matter. Seal knots, pitch streaks, and sappy sections. Fill nail holes with tinted exterior paintable caulking compound after prime coat has been applied.
- T. Exterior Wood Scheduled to Receive Transparent Finish: Remove dust, grit, and foreign matter; seal knots, pitch streaks, and sappy sections with sealer. Fill nail holes with tinted exterior caulking compound after sealer has been applied.
- U. Glue-Laminated Wood: Prior to finishing, wash surfaces with solvent, remove grease and dirt.
- V. Wood Doors Scheduled for Painting: Seal wood door top and bottom edge surfaces with clear sealer or tinted primer.
- W. Metal Doors Scheduled for Painting: Prime metal door top and bottom edge surfaces.

### 3.3 EXISTING WORK

- A. Extend existing paint and coatings installations using materials and methods compatible with existing installations and as specified.

### 3.4 APPLICATION

- A. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.
- B. Apply each coat to uniform appearance. Apply each coat of paint slightly darker than preceding coat unless specified otherwise.
- C. Sand wood and metal surfaces lightly between coats to achieve required finish.

- D. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.
- E. Where clear finishes are required, tint fillers to match wood. Work fillers into grain before set. Wipe excess from surface.
- F. Prime concealed surfaces of interior and exterior woodwork with primer paint.
- G. Prime concealed surfaces of interior wood surfaces scheduled to receive stain or varnish finish with gloss varnish reduced 25 percent with thinner.
- H. Finishing Mechanical and Electrical Equipment:
  - 1. Refer to Divisions 15 and 16 for schedule of color coding and identification banding of mechanical and electrical equipment, duct, piping, conduit, etc.
  - 2. Paint shop primed equipment.
  - 3. Remove unfinished louvers, grilles, covers, and access panels on mechanical and electrical components and paint separately.
  - 4. Prime and paint insulated and exposed pipes, conduit, boxes, insulated and exposed ducts, hangers, brackets, collars and supports, except where items are shop finished.
  - 5. Paint interior surfaces of air ducts and convector and baseboard heating cabinets visible through grilles and louvers with one coat of flat black paint to visible surfaces. Paint dampers exposed behind louvers, grilles, and convector and baseboard cabinets to match face panels.
  - 6. Paint exposed conduit and electrical equipment occurring in finished areas.
  - 7. Paint both sides and edges of plywood backboards for electrical and telephone equipment before installing equipment.
  - 8. Color code equipment, piping, conduit and exposed duct work in accordance with requirements indicated or color schedule. Color band and identify with flow arrows, names and numbering.
  - 9. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.
- I. Install Work as specified, as shown on drawings, in accordance with manufacturer's instructions, and to the satisfaction of the Engineer.

### 3.5 INSTALLATION - FIBER REINFORCED EPOXY COATING/LINING

- A. Prepare the surfaces including sandblasting and air cleaning.
- B. Apply one layer of an approved coal tar pitch epoxy coating, 200 microns thick, as per manufacturer's recommendations.
- C. Place one layer of approved fiberglass reinforcements before the applied epoxy coating is completely dry, as per manufacturer's recommendations.
- D. Apply another two layers of the approved coal tar pitch epoxy coating, 200 microns thick each.
- E. Place (if shown on drawings) plastic panel facing with approved adhesive materials.

### 3.6 FIELD QUALITY CONTROL

- A. General Requirements: Quality requirements for testing and inspection services, and execution requirements for testing, adjusting and balancing.
- B. Inspect and test questionable coated areas in accordance with applicable code.

### 3.7 CLEANING

- A. General Requirements: Execution requirements for final cleaning.
- B. Collect waste material which may constitute fire hazard, place in closed metal containers, and remove daily from site.

### 3.8 SCHEDULES - SHOP PRIMED ITEMS FOR SITE FINISHING

- A. Shop primed items for site finishing are stated under Division 5.

### 3.9 SCHEDULES - EXTERIOR SURFACES

- A. Pavement Markings:
  - 1. Two coats of thermoplastic reflectorized paint, yellow or white.
- B. Structural Steelwork: Refer to individual specification sections of Division 5.
- C. Architectural Steel - Unprimed:
  - 1. One coat of latex or alkyd primer.
  - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- D. Architectural Steel - Shop Primed:
  - 1. Touch-up with zinc chromate or zinc rich primer.
  - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- E. Architectural Steel - Galvanized:
  - 1. One coat galvanized primer.
  - 2. One mordant coat.
  - 3. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- F. Aluminum - Mill Finish:
  - 1. One coat etching primer.
  - 2. Two coats of alkyd enamel, gloss.
- G. Copper:
  - 1. One coat etching primer.
  - 2. Two coats of alkyd enamel, gloss.

### 3.10 SCHEDULES - INTERIOR SURFACES

- A. Concrete, Concrete Block, Restored Masonry and Cement Plaster:
  - 1. One coat of primer sealer latex or alkyd.
  - 2. Two coats of latex or alkyd, flat or semi-gloss.

- B. Structural Steelwork: Refer to individual specification sections of Division 5.
- C. Architectural Steel - Unprimed:
  - 1. One coat of alkyd or latex primer.
  - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- D. Architectural Steel - Primed:
  - 1. Touch-up with alkyd or latex primer.
  - 2. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- E. Architectural Steel - Galvanized:
  - 1. One coat galvanized primer.
  - 2. One mordant coat.
  - 3. Two coats of alkyd or latex enamel, gloss or semi-gloss.
- F. Aluminum - Mill Finish:
  - 1. One coat etching primer.
  - 2. Two coats of alkyd enamel, gloss.
- G. Concrete Floors:
  - 1. One coat of alkali resistant or catalyzed epoxy primer.
  - 2. Two coats of alkyd floor enamel or catalyzed epoxy enamel, gloss.

### 3.11 SCHEDULES

- A. As indicated on drawings and/or as selected by the Engineer.

END OF SECTION