

SECTION 01 86 36 –DRAINAGE SYSTEMS

1.01 ^{A7}SUMMARY:

- A. ^{A7}**Drainage:** This Section covers the design and construction of a drainage system to channel water in order to avoid accumulation of water or flooding of the facilities and Site.^{A7}
1. The system shall deal adequately with water from all sources including, but not limited, to the following:
- a. ^{A7}**Rainwater:** All elements required for drainage of rainwater along the lock walls, lock heads, and water-saving basins, and from buildings areas in which it may accumulate.^{A7}
 - b. ^{A7}**Road Drainage Water:** Water shall be collected from paved areas (roads, driveways, parking areas, etc.) by curb inlets with associated piping and gutters.^{A7}
 - c. ^{A7}**Firefighting:** Water from standpipes, sprinkler systems, and fire protection system.^{A7}
 - d. ^{A7}**Clear Wastes:** Service elements shall be provided as required for water-fountain drainage, condensate drainage, HVAC cooling water, drainage of clear wastes from building services and of water from cleaning operations (grease and oil shall be removed before discharging into the system).^{A7}
 - e. ^{A7}**Outdoor Areas:**^{A7} Drainage of outdoor areas where construction prevents natural drainage.
 - f. ^{A7}**Indoor Areas:** Drainage of indoor areas where water may accumulate naturally, including, but not limited to, sump pits and elevator pits.^{A7}
 - g. ^{A7}**Groundwater:** Subsurface drainage on the backside of each earth-retaining structure to prevent buildup of water-pressure load and liquefaction of the backfill.^{A7}

1.02 ^{A16}REFERENCES: ^{A16}

- A. ^{A7}**American Society for Testing and Materials (ASTM) International Standards.**^{A7}
- | | |
|---------------------------------------|--|
| ^{A7} C 270-07A ^{A7} | Mortar for Unit Masonry |
| ^{A7} C 443M-07 ^{A7} | Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric) |
| C 655M-04 | Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe (Metric) |
| D 75-03 | Sampling Aggregates |

D 1557-02	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³ (2,700 kN-m/m ³))
D 2167-94(01)	Density and Unit Weight of Soil in Place by the Rubber Balloon Method
D 2216-05	Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D 2487-06	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D 2855-96(02)	Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

^{A7}(deleted text)^{A7}

^{A7} D 3212-07 ^{A7}	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
F 402-05	Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
F 794-03	Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter

B. American Association of State Highway and Transportation Officials (AASHTO) Standard:

M 198-05	Joints for Concrete Pipe, Manholes and Precast Box Sections Using Flexible Joint Sealants
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1.03 ^{A7}REQUIREMENTS:^{A7}

A. ^{A7}General:^{A7}

1. Surface drainage shall be by gravity. ^{A7}Where drainage is to a sump that cannot discharge directly by gravity, sump pumps described in Section 01 86 13 (*Plant – Mechanical Systems and Equipment*) shall be used.^{A7}
2. ^{A7}The Contractor shall design and construct the Works so that water is not allowed to puddle or flow in an uncontrolled manner.^{A7}
3. Surfaces on which water will fall shall be designed to shed water into the drainage system.
4. ^{A7}The system shall incorporate adequate access points for cleaning and rodding, as well as a means for easy removal of accumulated debris.^{A7}

B. ^{A7}Buildings:^{A7}

1. Drainage from roofs shall be accomplished by means of roof drains.

2. Roof drain pipes shall be located outside the building wherever possible.
^{A7}When the pipes cannot be located outside the building, they shall be watertight pipes located within the walls.^{A7}
3. ^{A7}Rainwater leaders shall not be located in building entrances nor highly visible areas.^{A7} Leaders shall be secured appropriately and lead down to scuppers or concrete blocks connected to drainage conductors that lead to the site drain.
4. ^{A7}The Contractor shall ensure that the water does not hit the ground, create mud, and clog the area.^{A7}
5. Floor drains shall be flush with the surface on which they are installed, out of pedestrian traffic patterns wherever possible, and covered with a grate.
6. Roof drains shall be provided with a means to avoid clogging with leaves or other obstructions.

C. ^{A7}**Site:**^{A7}

1. ^{A7}**Surface Drainage:**^{A7}
 - a. Drain inlets shall be flush with the surface on which they are installed.
^{A7}Openings shall be covered with grating having the capacity to support the traffic in the area and permit the flow of water, but avoid the entry of rodents or birds.^{A7}
 - b. Trench drains shall be flush with the surface and have covers or grating with the capacity to support the traffic in the area. Openings shall permit the flow of water but avoid the entry of rodents or birds.
 - c. Grating and covers shall withstand repetitive loading without damage or undue wear.
 - d. Trench drains shall have replaceable covers or grates for ease of maintenance or repair.
 - e. ^{A7}In areas where pedestrian traffic is the only type of traffic allowed, grating shall have a non-slip surface.^{A7}
 - f. Covers and gratings shall be corrosion resistant.
 - g. Water flow shall be directed away from the chamber and into the drainage system.

D. ^{A7}**Areas Behind Earth Retaining Structures:**^{A7}

1. ^{A7}**Subsurface Drainage:**^{A7}
 - a. Active groundwater control behind the structure.
 - b. Groundwater collection system shall consist of:
 - 1) ^{A7}Perforated or slotted PVC or polyethylene (PE) drainage pipe, with sufficient strength to withstand the loads as applied in the structural calculation of the earth-retaining structure.^{A7}

- 2) ^{A7}Continuous envelope pocket of graded granular filter material to retain fine earth particles and to prevent them from entering the drainage pipe.^{A7}
- 3) ^{A7}Geotextile-filter fabric as a separation between envelope pocket and backfill material.^{A7}
- c. ^{A7}Minimum diameter shall be 160 mm.^{A7}
- d. ^{A7}The drainage lines shall be equipped with facilities for flushing by traveling high-pressure nozzle heads.^{A7}
- e. ^{A7}Discharge to surface water by means of nonreturn valves, if required. The valves shall be easily accessible for inspection, maintenance, and replacement.^{A7}

E. Products:

- 1. **Pipe:** Do not use:
 - a. Clay pipe.
 - b. Copper tube or pipe.
 - c. ABS pipe and fittings.
- 2. **Culverts:** Do not use:
 - a. Galvanized corrugated steel pipe.
 - b. ^{A7}Aluminum-coated steel pipe.^{A7}
- 3. **Storm Drains:** Design shall take account of the following general principles:
 - a. All slabs in the underground structures shall be reinforced concrete.
 - b. ^{A7}The minimum thickness of all shaft walls, including ventilation shafts, shall be 30 cm.^{A7}
 - c. ^{A7}Minimum cover for reinforcement shall be as required by Section 03 30 00 (*Concrete*).^{A7}
 - d. ^{A7}Continuous reinforcement at the top and bottom in floors and roofs shall be specified in the design and construction drawings.^{A7}
 - e. ^{A7}The concrete shall be designed in accordance with Section 03 30 00 (*Concrete*).^{A7}
 - f. Do not use:
 - 1) Stainless steel.
 - 2) Bronze.
- 4. **Manholes:** Use one or more of the following:

- a. Prefabricated concrete
 - b. Cast-in-place concrete
 - c. ^{A7}Covers shall be as shown on ACP standard drawings L-2660-1, L-2660-2, and L-2660-3 [included in Volume II, Part 4](#); and shall be suitable for the loads to which they will be subjected.^{A7}
5. ^{A7}**Sump Pumps:** Refer to Section 01 86 13 (*Plant – Mechanical Systems and Equipment*).^{A7}
 6. ^{A7}**Nonreturn Valves:** Use galvanized steel.^{A7}

1.04 DESIGN CRITERIA/SYSTEM DESCRIPTION AND PERFORMANCE:

A. Design:

1. ^{A7}The drainage system shall be designed for a 50 year design life.^{A7}
2. ^{A7}The storm sewer system shall provide a minimum of 20 years of service without major repairs or operating expense.^{A7}
3. [The Contractor's design may consider the meteorological information provided in Volume VI, Part 7 \(*Hydrometeorological Report*\), and the fire-protection and sprinkler systems described in Section 01 86 13 \(*Plant – Mechanical Systems and Equipment*\). See Clause 5.1 of the Conditions of Contract regarding all information in Volume VI.](#)
4. ^{A7}The Contractor shall estimate the maximum volume and rate of flow arising from the worst combination of sources and design the system accordingly.^{A7}
5. Minimum pipe size shall be 150 mm.
6. Minimum pipe or trench slope for horizontal surfaces shall be as required to maintain scouring velocity.
7. ^{A7}Maximum manhole spacing shall be 90 m. There shall be one manhole in every change of direction in the storm-sewer system pipe.^{A7}
8. ^{A7}Maximum cleanout spacing shall be 30 m.^{A7}
9. The design and construction of side ditches shall conform to general practice and shall include provisions for controlling erosion. Earth ditches will not be acceptable.
10. Head walls shall be designed according to standard practice for the drains and conditions of each location. The entrance shall be protected by trash screens.
11. Trash screens shall be coated with a system that provides protection for 20 years.
12. The following design storms shall be used:
 - a. ^{A7}**Trench Drains:** 5 years.^{A7}
 - b. ^{A7}**Roadside Ditches:** 5 years.^{A7}
 - c. ^{A7}**Cross-Drain Structures:** 50 years.^{A7}

- d. ^{A7}**Subsurface Drain Structures:** Drainage pipes - 50 year-lifetime; nonreturn valves - 20 years.^{A7}
- e. ^{A7}**Roof Drains:** 5 years.^{A7}
- 13. Pipe materials shall be standard materials accepted in the construction industry that will provide the desired service life.
- 14. [A set of standard drawings that satisfy the Employers minimum requirements have been included in Volume II, Part 4 \(Requirement Drawings\).](#) If they satisfy the Contractor's design requirements they may be used.
- ^{A16}15. The Employer has identified components of the Works that are to be designed by the Contractor but not constructed. The design shall include all requirements that will permit the system to function with the components that are constructed by the Contractor. The Contractor's design shall also permit the Employer to construct and connect the remaining components to the drainage system at a later date.^{A16}

1.05 SUBMITTALS: ^{A7}All drawings and other submittals shall be submitted in accordance with the requirements of Section 01 33 00 (*Submittal Procedures*) and the requirements of this Section for the following phases:^{A7}

A. ^{A16}**Intermediate Design:** When design has advanced sufficiently to permit the Employer to review the design submitted, the Contractor shall submit the following:^{A16}

- 1. ^{A7}**Drawings Showing:**^{A7}
 - a. ^{A7}Locations, alignment, and profile of the drainage system.^{A7}
 - b. Invert elevations, pipe and trench slopes, and proposed finished grade elevations above top of pipe.
 - c. The calculated hydraulic grade line.
 - d. Location and details for open drains, pipe drains, outlets, trash screens, and sumps.
 - e. Cross section showing the location of potential utility conflicts.
- 2. **Documentation:**
 - a. ^{A7}Preliminary data, starting points, and calculations related to the design of the drainage system, as well as the rationale for selecting the system.^{A7}
 - b. Evidence that the drainage designs meet all drainage performance criteria.
 - c. ^{A7}A preliminary storm-water management plan.^{A7}

B. ^{A16}**Final Design:** After completion of final design and a minimum 42 days before construction begins the Contractor shall submit the following for review:^{A16}

- 1. ^{A7}**Final Drawings Showing:**^{A7}

- a. ^{A7}Locations, alignment, and profile of the drainage system.^{A7}
 - b. ^{A7}Invert elevations, trench and pipe slopes, outlets, wash-outs, and flushing points. Proposed finished grade elevations above top of pipe.^{A7}
 - c. The calculated hydraulic grade line.
 - d. Location and details for open drains, pipe drains, outlets, trash screens, and sumps.
 2. **Documentation:**
 - a. ^{A7}All data and calculations related to the design of the drainage system, as well as the rationale for selecting the system.^{A7}
 - b. Evidence that the drainage designs meet all drainage performance criteria.
 - c. ^{A7}A storm-water management plan.^{A7}
- C. ^{A16}**Construction:** 28 days before construction begins the Contractor shall submit the following for review:^{A16}
1. ^{A7}**Drawings Showing:**^{A7}
 - a. The proposed construction methods for the drainage system.
 2. **Documentation:**
 - a. ^{A7}Certificates of compliance attesting that the pipes, prefabricated shafts and manholes, manhole covers, nonreturn valves, culverts, fittings, and joining materials meet the design requirements.^{A7}
 - b. Certificates attesting that tests set forth in each applicable referenced publication have been performed, whether specified in the publications to be mandatory or otherwise, and that production control tests have been performed at the frequency or intervals specified in the publications.
 - c. ^{A7}Manufacturer's catalogue data for piping, including fittings and joining materials, nonreturn valves, etc.^{A7}
 - d. Manufacturer's catalogue data for prefabricated manholes, shafts, etc., with appurtenances.
- D. ^{A16}**After Construction:** The Contractor shall submit the following for approval:^{A16}
1. **Drawings:**
 - a. ^{A16}As-Built Drawings.^{A16}

1.06 QUALITY ASSURANCE:

- A. ^{A7}Verify conformance with the requirements of this Section. All requirements in Section 01 40 00 (*Quality Requirements*) shall apply to this section.^{A7}

B. ^{A16}General Testing and Procedures for approval: ^{A16}

1. Submit a list and technical data of instruments and equipment for inspection and testing.
2. ^{A7}Submit explanation of how quality-control testing will be performed.^{A7}
3. ^{A7}Submit technical procedures and methods of performing quality-control inspections for all features of the work.^{A7}

END OF SECTION