AREMA

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION

Part 4

Culverts[1]

— 2018 —

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4.10.2.2 FRPM Fittings

Fittings shall conform to ASTM D3840. Dimensions of specific fittings shall be as agreed between purchaser and manufacturer. Installed fittings shall meet or exceed the pipe structural performance.

4.10.3 FIELD JOINT CONNECTIONS (2015)

4.10.3.1 General

All joints shall be gasket-sealed, compression fit and shall be water-tight according to ASTM D4161. Gaskets shall meet the requirements of ASTM F477. Manufacturer shall provide the required non-oil based joint assembly lubricant.

4.10.3.2 Couplings

Couplings consist of a fiberglass reinforced body and a full or partial width, interior sealing gasket. The gaskets, which seal in compression to the pipe OD surface, shall be integral with the coupling as manufactured. This joint shall be used for all open cut installations and may be used in 2-pass tunnels (carrier pipe). No shipping or storage protection is necessary if the gasket is EPDM elastomer (very highly UV resistant). If the gasket becomes dislodged, replace the coupling (press-on fit). Oil resistant Nitrile (Buna-N) gaskets may also be used. Manufacturer to advise any special precautions for these gaskets.

4.10.3.3 Bell & Spigot

4.10.3.3.1 Raised Bell

A raised bell-spigot joint consists of a "raised" (OD larger than pipe), fixed ID bell and a fixed OD spigot (opposite end) with a groove to retain the sealing gasket. Gasket shall be placed on the spigot in the field just prior to assembly. This joint may be used in sliplining and 2-pass tunnel installations.

4.10.3.3.2 Flush Bell

A flush bell-spigot joint consists of a flush (OD essentially the same as the pipe), fixed ID bell and a fixed OD spigot (opposite end) with smaller (reduced OD to enter the bell) with a groove to retain the sealing gasket. Gasket shall be placed on the spigot in the field just prior to assembly. This joint shall be used in direct jacking & microtunneling installations, and may be used in sliplining and 2-pass tunnels.

SECTION 4.11 SPECIFICATIONS FOR STEEL REINFORCED POLYETHYLENE PIPE

4.11.1 GENERAL (2018)

This specification covers steel reinforced polyethylene pipe for under track culverts and storm drain applications.

4.11.2 MATERIALS (2018)

4.11.2.1 Steel Reinforced Polyethylene Pipe

30 through 120-inch diameter Steel Reinforced Polyethylene Pipe shall be fabricated per the requirements of ASTM F2562 "Standard Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage." Polyethylene materials used in the manufacture of steel reinforced polyethylene pipe shall meet or exceed the material and cell classification requirements of ASTM F2562 and AASHTO MP-20, as defined and described in Specification ASTM D3350. If there are discrepancies in the resin properties listed in the referenced specifications, the higher quality resin

properties shall be used. The steel material shall be cold or hot rolled formable steel meeting the requirements of either ASTM Specification A1008 or A1011.

4.11.2.2 Steel Reinforced Polyethylene Fittings and Joining Systems

Joints and fittings for Steel Reinforced Polyethylene pipe shall conform to ASTM F 2562. Joining systems include coupling bands with gaskets, bell and spigot joints, and welded joints. Joint type should be selected based on the project specific requirements and expectations related to soil tight, low head, high head or pressure tested performance.

4.11.2.3 Installation

Steel reinforced polyethylene pipe should be installed per ASTM D2321 or AASHTO Load and Resistance Factor Design (LRFD) Bridge Construction Specification Section 26 and in accordance with the manufacturer's recommendations. Guidance for pipe "Inspection Requirements" should follow the AASHTO LRFD Bridge Construction Specification Section 26.

SECTION 4.12 HYDRAULICS OF CULVERTS

4.12.1 INTRODUCTION (1989)

a. Designing a culvert has not yet reached the stage where two or more individuals will always arrive at the same answer, or where actual service performance matches the designer's anticipation. The reason is that the engineer's interpretation of field data and hydrology is often influenced by personal judgment, based on his own experience in a given locality. However, field data, hydrology and hydraulic research are closing the gap to move the art of designing a culvert a little closer to becoming a science.

b. Up to this point, the design procedure has consisted of collecting field data, compiling facts about the roadway, and making a reasonable estimate of flood flow for a chosen frequency. The fourth step is to design an economical culvert to handle the flow (including debris) with minimum damage to the right of way or adjacent property.

c. Factors to consider include: type of structure; area and shape of waterway opening; approximate length and slope of culvert barrel; and treatment of inlet and outlet ends.

4.12.2 DESIGN METHOD (1989)

a. The culvert design process shall strive for a balanced result. Pure fluid mechanics should be combined with practical considerations to help assure satisfactory performance under actual field conditions. This includes prospective maintenance and the handling of debris.

b. As a minimum, it is recommended that the culvert shall be designed to discharge:

(1) a 25-year flood without static head at entrance, and

(2) a 100-year flood using the available head at entrance, the head to 2 feet below base of rail, or the head to a depth of 1.5 times the culvert diameter/rise, whichever is less.

c. This approach lends itself well to most modern design processes and computer programs such as those published by the Federal Highway Administration (Reference 21). It applies a usable rational control to the elusive matter of minimum waterway area which constitutes good practice. This design method is highly recommended and is followed here in conjunction with the Federal Highway Administration charts (Reference 22). However, the final decision

4.16.4 PROPERTIES (2015)

4.16.4.1 Pipe

Because of variable ingredient ratios and reinforcement orientation alternatives, specific or minimum properties cannot be stated. Properties and allowable strains are derived from the results of short and long-term test values reduced by specified safety margins where appropriate. Pipe manufacturer shall provide design properties and short & long-term test reports to support values used in design calculations. Required properties include hoop flexural modulus, compressive strength and the long-term ring bending strain per ASTM D2412, D695 and D3262 respectively.

4.16.4.2 Soils

Moduli for native soils are given in AWWA M45 Chapter 5 based on Standard Penetration Test (SPT) blow counts or unconfined compression tests and shall be used. Moduli for pipe zone backfill (also given in AWWA M45) are variable with material, compaction (density) and depth (confinement pressure), and shall be used (note these are the same values as adopted in the AASHTO design specifications). These two moduli are combined per procedures given in AWWA M45 to generate the soil support component used in design calculations.

4.16.5 INSTALLATION (2015)

4.16.5.1 Open Cut

Buried installation shall be designed to meet project conditions and shall be in accordance with ASTM D3839.

4.16.5.2 Sliplining

FRPM pipes, typically with raised or flush gasket sealed joints, are suitable for sliplining rehabilitation of existing culverts and sewers in accordance with Section 4.21.

4.16.5.3 2-Pass Tunneling

FRPM pipes, typically with raised or flush gasket sealed joints, are suitable for installation as the water-way carrier pipe inside of a casing (such as liner plate or steel casing or similar) in general accordance with the installation practices described in Section 4.21.

4.16.5.4 Direct Jacking & Microtunneling

FRPM pipes with flush joint sealed joints are suitable for direct jacking installation in accordance with Section 4.20 Additional information may be found in ASCE 36-14, Standard Construction Guidelines for Microtunneling.

SECTION 4.17 STRUCTURAL DESIGN CONSIDERATIONS OF STEEL REINFORCED POLYETHYLENE (SRPE) PIPES

4.17.1 INTRODUCTION (2018)

Steel reinforced polyethylene pipe has a smooth waterway wall and an exterior profile that is reinforced with steel ribs. The reinforcing ribs are completely encased within the polyethylene profile. The main load carrying members of the SRPE pipe are steel ribs. The ribs are encapsulated by thermoplastic material to brace the ribs from distortion and buckling.

4.17.2 DESIGN CRITERIA (2018)

The structural design of SRPE pipe follows the Load Resistance Factor Design (LRFD) Methodology from Section 12 Buried Structures and Tunnel Liners of the AASHTO LRFD Bridge Specifications. The profile of the SRPE pipe product shall be evaluated according to the AASHTO LRFD Bridge Specifications, Section 12.7.2.7. The pipe's profile dimensions, including section properties necessary for the completion of Section 12 analysis, shall be provided by manufacturer upon request.

4.17.3 LOADS AND LOAD FACTORS (2018)

4.17.3.1 General Comments

Section 3 Loads and Load Factors of the AASHTO LRFD Bridge Specification defines most loads and load factors for SRPE pipe. Additional guidelines are presented herein. The method is based on calculating the thrust in the pipe wall and investigating the limit state for wall area and buckling strength.

NOTE: Since the steel is the main load carrying member, SRPE pipe behaves structurally as a metal pipe and is grouped with metal pipe in the AASHTO LRFD specification. The structural design procedure therefore uses the same formulas as for metal pipe.

4.17.3.2 Load Factors and Combinations

Loads and Load Factors are determined in section 3 of the AASHTO LRFD Bridge Specifications. Strength 1 Limit State load factors will be the controlling case.

4.17.3.3 Permanent Loads

Permanent Loads consist of Dead Loads and Earth loads as contained in Section 3 Loads and Load Factors of the AASHTO LRFD Bridge Specifications.

4.17.3.4 Live Loads

Cooper E-80 live loads are normally used as the basis for determining live load pressures for under track culvert design. These live load pressures are provided in Table 1-4-24 of the AREMA Manual and include an impact factor of 50%. Use the E-80 live load pressure as the value for P_L, live load vertical crown pressure, in the AASHTO formulas. The factored live load vertical crown pressure, P_{FL}, per AASHTO LRFD section 12.7.2.2: $P_{FL} = \eta_{LL}\gamma_{LL}P_L$, where P_L is the live load pressure per AREMA Table 1-4-24, and η_{LL} and γ_{LL} are factors as defined in AASHTO LRFD.

SECTION 4.18 CULVERT END TREATMENTS

4.18.1 INTRODUCTION (2012)

a. The design and installation of each culvert should be considered as an individual engineering and economic problem. The engineer should determine the basic requirements of type, strength, capacity, service, location, alignment, grade, subgrade/foundation suitability and other factors pertinent to the efficient function and economic installation and maintenance of the culvert.

b. In addition, the engineer should decide if the physical conditions at the culvert site - flow conditions, culvert alignment situation and soil slope conditions - both at the present and during the projected life of the culvert - warrant the inclusion of headwalls, wingwalls, inverts, aprons, end sections or combinations of these as part of the installation.