Resources and Required Reading

Required Reading:
AASHTO Specifications
- Section 12 LRFD
- Section 26 LRFD
- Section 30 LRFD
- M 36
- M 294
- M 304

ASTM Specifications
- D 2321
- F 2562
- F 949
- What is ASTM International
- http://www.astm.org/FAQ/
- F 2736
- F 2764

Suggested Reading:
- ASTM A 796
- ASTM A 760
- ASTM F 2306
- ASTM A 762

Course Description

The purpose of this course is to provide the student with a basic knowledge of where to find relevant information regarding competitive pipe products in national standards. The course covers a substantial quantity of material. It is advisable to make notations and bookmark the specifications as you study to make future reference for test purposes and for dealing with competitive product issues easier.

The focus will be threefold:

1. to provide a resource of specifications and an understanding of the content of those specifications that can be referred to on an as needed basis.
2. to review some of the core specifications.
3. to provide an overview of the process undertaken in the development of national standards.

One important point to remember is that the national standards referenced in this course are constantly evolving. An outdated specification may not be representative of the current specification. In addition, new specifications are developed frequently, especially as they relate to new products. So, always be on the lookout for those new specifications and review them as if you were studying for an exam.

Given the wide breadth of specifications that could be referenced for some products, some specifications may not be discussed in this course. This may have been intentional due to the
obscurity of a certain specification or a specification of importance may have been overlooked
unintentionally. If you feel a specification of importance has not been included, please feel free
to forward that information to the ACPA. Another factor considered for the preparation of this
course is the cost and infrequent use of some specifications. The intent of this course is to
provide an understanding of the content of certain specifications and discuss the relevant
portions of those specifications without requiring their purchase. If a student has a desire to
more thoroughly review a specification that is not required reading, they may certainly pursue
the acquisition of that specification and is encouraged to do so.

The outline for this course is as follows:

1. Terminology (Terms to Know)
2. National Standards
3. Product Specific Standards
4. Specification Chart

Good luck and enjoy the learning experience!

**TERMS TO KNOW**

- Polyvinyl Chloride (PVC)
- Acrylonitrile Butadiene Styrene (ABS)
- Resin
- High Density Polyethylene (HDPE)
- Polypropylene
- Steel Reinforced HDPE (SRHDPE)
- Corrugated Steel Pipe (CSP)
- Corrugation Profile
- Polymer Coating
- Aluminized Type 2
- Galvanized Coating
- Zinc Coating
- Asphalt Coating
- Bituminous Coating
- Pipe Stiffness
- Deflection
- Buckling
- Trench Width
- Committee
- Subcommittee
- American Association of State Highway and Transportation Officials (AASHTO)
- ASTM International (Originally known as American Society for Testing and Materials)

**NATIONAL STANDARDS**

The two main agencies that develop national standards affecting our industry are ASTM and
AASHTO. Almost all engineers, owners, developers, and government agencies reference the
standards of one or both of these agencies in project specifications. The make-up of the
organizations and the process used to develop a given standard will be a main focus of this
section.

**ASTM International** – Originally known as American Society for Testing and
Materials, is one of the largest voluntary standards development organizations in the world.
ASTM plays a leadership role in addressing the standardization needs of the global marketplace.
Standards developed at ASTM are the work of over 30,000 ASTM members. These technical
experts represent producers, users, consumers, government, and academia from over 120
countries. Participation in ASTM International is open to all with a material interest, anywhere
in the world.

As used in ASTM, a standard is a document that has been developed and established within the
consensus principles of the organization and which meets the requirements of ASTM procedures
and regulations. Full consensus standards are developed with the participation of all parties who have a stake in the standards’ development and/or use. ASTM standards are often cited in laws, regulations, codes, and project documents by government and private entities. ASTM is important to the Concrete Pipe industry due to ASTM standards being used and referenced in project specifications. The scope of what these standards cover is very broad. They cover manufacturing requirements, raw material quality, installation procedures, product design and testing, life cycle analysis, etc. Given the scope, wide spread use, and influence of ASTM standards it is important to understand how and by who they are developed. Questions pertaining to the ASTM Standards process and membership requirements will be included on the test for this course.

The ASTM technical committees that cover CSP and thermoplastic pipe are shown below.

- Committee A05.17 on Corrugated Steel Pipe Specifications
- Committee F17 on Plastic Piping Systems
  - Subcommittee F17.62 – Sewer
  - Subcommittee F17.65 – Land Drainage
- Committee C13 – Concrete Pipe

The ACPA Technical Committee, ACPA staff, and other concerned members actively participate on appropriate ASTM committees and subcommittees as they relate to competitive products as well as those pertaining to the Concrete Pipe Industry.

**AASHTO** – The stated “Vision” for AASHTO is “The American Association of State Highway and Transportation Officials is the voice for transportation and catalyst for organizational and technical excellence.” An overview of the organization and their purpose is as follows: “AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.”

The membership of the American Association of State Highway and Transportation Officials is composed only of instrumentalities of government. The membership shall be those Departments or Agencies of the States of the United States, Puerto Rico, and the District of Columbia in which the official highway responsibility for that State or Territory is lodged, and the United States Department of Transportation, which is an ex-officio member. Committees comprised of member department personnel who serve voluntarily do much of AASHTO’s work. AASHTO's Standing Committee on Highways (SCOH) is the foundation for the AASHTO transportation family – AASHTO started as a highways and roads association back in 1914. Today SCOH provides and represents the technical expertise of AASHTO. SCOH manages the development of policies, guidelines, standards, and publications.

Each member Department of Transportation (DOT) is entitled to a seat on this standing committee. The Chief Executive Officer (CEO) of the member DOT assigns a representative, who is most often the DOT's Chief Engineer. The committee officers include the chair, vice-chair, secretary, and AASHTO liaison. The voting members total 52. SCOH meets twice each year, at the AASHTO Annual Meeting and the AASHTO Spring Meeting. Its subcommittees, task forces, and other special groups, largely do the committee's extensive work and report activities to the standing committee officers and voting members. The members of SCOH - the chief engineers - oversee the business and work of SCOH's subcommittees.
The subcommittees that are of particular interest to the Concrete Pipe Industry are:

Subcommittee on Bridges and Structures
Subcommittee on Materials
Technical Section 4a – Rigid Pipe
Technical Section 4b – Flexible and Metallic Pipe

These subcommittees and their specific technical and liaison committees deal with product specifics as they relate to design, manufacture, and material properties. Other noteworthy subcommittees due to their involvement with concrete and competitive pipe products are:

Subcommittee on Construction
Subcommittee on Design

Doing some research on the AASHTO website and discovering your state DOT personnel that are active committee members will allow you another opportunity to visit with them regarding important industry topics.

PRODUCT SPECIFIC STANDARDS (SPECIFICATIONS)
This section discusses relevant specifications for each competitive product. The specifications discussed cover raw materials, design, manufacturing, and installation. The intent is to understand the formatting of the specifications and to point out important issues in specific specifications. This knowledge will prove beneficial in sales and marketing efforts with contractors, engineers, and owners.

CSP – Corrugated steel pipe comes in a variety of shapes and sizes. These shapes and sizes are supplemented further by numerous corrugations (wall profiles) and pipe wall thicknesses (gage) that directly affect the structural design characteristics of the product. The world of CSP is further complicated by an assortment of coatings used to enhance the product’s durability. In addition to CSP machine produced in a plant/facility, Corrugated Aluminum pipe (CAP), Long-Span (Structural Plate) structures that are bolted together on a jobsite, and some other configurations are discussed in the specifications that will be discussed. Studying the material as presented should prepare an individual to investigate these products on an as needed basis. For a specific geographic area they may be worth knowing about and maybe extremely relevant, however for the purposes of this course only machine produced (spiral or helical) CSP will be discussed.

Given the assortment of options available with CSP, several specifications have developed over time addressing specific attributes. This discussion will not delve into each individual specification, but will focus on the core specifications. Studying this material should prepare an individual to perform additional research on an as needed basis.

While reviewing these specifications be thinking about the weaknesses of CSP. Do the specifications address these weaknesses? If the weaknesses are addressed what are the shortcomings?

Design
Understanding the design philosophy is important as well as the differences in ASTM and AASHTO specifications.
This ASTM was not listed under required readings, as the main ideas are presented in this write-up.

**Important Elements of Specification**

- 12 recognized corrugation patterns + Smooth Lined (Double Wall) pipe (Corrugated exterior wall with smooth liner). Not all corrugation patterns are widely produced or accepted.
- Section 17.2.5 has the following definition for the structural soil envelope: “The size of the structural soil envelope shall be 2 ft [600 mm] minimum each side for trench installations and one diameter minimum each side for embankment installations. This structural soil envelope shall extend at least 1 ft [300 mm] above the top of the pipe.”
- There is no requirement for a deflection limit.
- Minimum spacing for multiple lines of pipe is addressed as the following:
  - Pipe diameter greater than 48 in. [1200 mm] in diameter or span shall be spaced so that the sides of the pipe shall be no closer than one half of a diameter or 3 ft [900 mm], whichever is less.
  - For diameters up to 48 in. [1200 mm], the minimum distance between the sides of the pipes shall be no less than 2 ft [600 mm].

**AASHTO LRFD Bridge Design Specifications, Section 12**

Section 12 is a comprehensive design specification covering a wide variety of buried structures. Section 12.7 covers metal pipe, pipe arch, and arch structures. In addition to the design process, which has some variations as compared to the ASTM procedure, the following are important elements of the specification as they relate to CSP.

- Corrugation profiles
- Structural Soil envelope
- Minimum space requirements for multiple lines of pipe
- Flexibility limits
- Even though Section 12 does not directly provide the factored load equation for CSP (it is referenced and requires some digging), it is the same as the ASTM factored load equation

**Manufacturing**

**ASTM - A 760 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains**

**AASHTO – M36 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains**

**Important Elements of Specification**

- Pipe Classifications
- Corrugation tolerances
- Lock seam tensile strengths
- Pipe end tolerances
- Pipe diameter tolerances
- Pipe length tolerance
• Joining systems
• Repair of damaged coatings
• Inspection allowances
• Rejection

Installation

ASTM - A 798 - Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications

Important Elements of Specification

• Trench detail
  o For trench widths less than 24”, bedding to be shaped to pipe invert for a width of D/2
  o Structural back fill to be placed in 6 -12 inch lifts and then compacted
  o Encapsulation zone is to be the greater of D/8 or 12 inches above the top of the pipe
  o The trench width is not called out other than to be beyond the minimum required for proper installation.

• Embankment detail
  o Structural fill to be the lesser of 1 diameter or 2 feet on each side of the pipe

• Yielding foundation
  o It is recommended for large pipe to provide a foundation under the pipe that will yield more under load than the foundation under the soil prisms on each side.

• Pipe-arches
  o Required to have “excellent” soil support at the corners from both the in-situ soils and the structural backfill

• Bedding
  o Material in contact with the pipe shall not contain rock retained on a 3” ring

• Pipe handling
  o Pipe is to be handled with reasonable care. It is not to be dragged over rock or hard objects. Pipe with protective coatings are to receive special care.

• Deflection control
  o No stated limits

AASHTO - Standard Specifications for Highway Bridges, Division II, Section 26

Important Elements of Specification

• Dissimilar materials
  o Dissimilar materials are not allowed to be mixed in an installation without a means of separation or protection from galvanic reaction

• Polymeric coating
  o Pinholes, blisters, cracks, or lack of bonding is cause for rejection

• Bedding
- Maximum particle size of one-half the corrugation depth
- Structural backfill
  - Maximum of 3 inch rock fragments
- Pipe handling
  - No significant difference from ASTM
- Joint couplers
  - Standard and Special joints
  - Soil tightness and Watertightness
  (Advisable to know the difference and the requirements)
- Foundation
  - Foundation shall be investigated to ensure that the structural backfill does not settle more than the pipe
- Backfill
  - Loose layers not exceeding 8 inches
  - Raised evenly on both sides with a differential not to exceed 24 inches or one-third the rise of the pipe, whichever is less
- Inspection
  - This is an extremely important section of the specification and has the potential to account for many test questions

**HDPE** – High Density Polyethylene Pipe has been produced in a variety of wall profiles in recent years. Many of those profiles are no longer produced. The procedure of trying new profiles is expected to continue as the industry strives to maximize efficiency and increase their size range. Another current effort is to utilize recycled resin in the manufacturing process.

**Design**

**ASTM** – ASTM does not currently have a design standard for HDPE

**AASHTO** – Standard Specifications for Highway Bridges, Section 12

**Important Elements of Specification**

- Section 12.12 covers the structural design of pipe products manufactured from PE or PVC
- The design deflection limit is 5% reduction of the vertical diameter
- Service limit states
  - Chemical and Mechanical requirements
    - Cell classification and meaning
    - Design tensile strengths
  - Structural tests for failure
    - Know the formulas and understand the requirements for determining thrust, buckling, and combined strain requirements for the pipe wall.

A general understanding of these formulas is required, although computations will not be required

- Trench width requirements
- Flexibility factors

**Manufacture**

**ASTM - F 2306** - Specification for 12 in. to 60 in. (300 -1500 mm) Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications

© 2008 American Concrete Pipe Association, all rights reserved
**AASHTO - M 294 - Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter**

**Important Elements of Specification**
- Note 1 in the scope of the specification clearly states that when the ends are exposed there should be concern regarding UV degradation and combustibility
- The terminology list is worth being familiar with as a means of identifying potential problems and understanding potential issues with the product
- Recognition of the different Types covered by this specification
- Pipe tolerances in regard to length, diameter, and wall thickness
- Pipe stiffness requirements
- Joint types and requirements
- Test procedures
- Retest and rejection requirements
- Annex A – Mandatory information
- Steps, procedures, requirements of optional Quality control/Quality assurance program

**Installation**

**ASTM – D 2321 Standard Practice for Underground Installation of thermoplastic Pipe for Sewers and Other Gravity-Flow Applications**

**Important Elements of Specification**
- Pipe embedment zone calls for 6” to 12” above top of pipe
- Trench width requirements
- Trench wall support requirements and their significance
- Placing and compacting pipe embedment
- Minimum cover
- Deflection control and monitoring requirements

**AASHTO - LRFD Bridge Construction Specifications, Section 30 - Thermoplastic Pipe**

**Important Elements of Specification**
- Bedding & Backfill
  - Gradation requirements
  - Maximum particle size
- Field Joints
  - Watertightness options
- Open trench requirements
  - Follow applicable safety standards
  - All trenches shall be backfilled by days end
- Trench details
  - Pipe embedment zone is a minimum of 1 foot over pipe
  - Minimum trench width shall not be less than 1.5 times the pipe diameter plus 12 inches
  - The middle third (Dv/3) of the bedding should be loosely placed
Loose lift thickness for structural backfill is a maximum of 8 inches brought up uniformly on both sides of the pipe. Minimum fill height for vehicular loads is 2 feet.

- **Inspection**
  - **Visual inspection**
    - 100% of all pipes shall be visually inspected.
    - All pipes shall undergo inspection during and after installation.
    - Final inspection shall be done no sooner than 30 days after installation and final fill.

- **Deflection**
  - Not to exceed 5% after 30 days.
  - 10% of pipe runs representing 10% of total footage on project shall be deflection tested.
  - Where deflection exceeds 5% pipe an evaluation shall be submitted to the engineer for review.
  - When pipe deflection exceeds 7.5%, the pipe is to be remediated or replaced.

**SRHDPE** – Steel Reinforced High Density Polyethylene Pipe is a newcomer to the marketplace as of the writing of this lesson. Early reports indicate some significant issues to overcome before the product is a viable option in the culvert and storm sewer market. Time will tell if these are quality control problems or inherent problems with the product itself. Of course, the product could be reinvented as the HDPE products have been over the course of their short life span.

**Design**

- **ASTM** – N/A
- **AASHTO** – N/A

Manufacturer promoting the use of CSP structural design standards for SRHDPE.

**Manufacture**

- **ASTM** - F 2562 - Specification for Steel Reinforced Polyethylene (PE) Corrugated Pipe

**Important Elements of Specification**
- Size range covered by specification
- Available stiffness classes
- Stiffness classes at what deflection percentage
- Resin cell classifications required
- Steel requirements
- Pipe size tolerances
- Minimum wall thickness
- Encapsulation thicknesses
- Available joint types for tightness
- Inspection and rejection procedures

- **AASHTO** – MP 20-10. This is a provisional specification.

**Installation**

- **ASTM** – D 2321 Recommended per ASTM F 2562
AASHTO – Section 30 LRFD. This standard covers the installation of thermoplastic materials. Although, SRHDPE pipe is not specifically called out, PE is included in the definition of thermoplastic pipe materials.

Polypropylene – As a newcomer to the U.S. storm drain market, the design, production, and installation specifications are in their infancy. For the most part, they are mimicking the HDPE specifications. Pipe stiffness varies between the current ASTM manufacturing specifications and the proposed AASHTO manufacturing standard. The current AASHTO design and installation standards do not list polypropylene as a covered thermoplastic material.

Design
ASTM – N/A

AASHTO – Although, AASHTO LRFD Section 12 does not refer to or include Polypropylene, it is widely accepted that the design process will cover polypropylene pipe. The material properties used for the design are found in the ASTM manufacturing specifications.

Manufacture
ASTM - F 2736 Standard Specification for 6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe
ASTM - F 2764 Standard Specification for 30 to 60 in. [750 to 1500 mm] Polypropylene (PP) Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications
AASHTO – N/A as of December 2010, although a specification is being balloted

Installation
ASTM – D 2321
AASHTO – LRFD Bridge Construction Specifications, Section 30 - Thermoplastic Pipe – Although, not specifically referenced in the AASHTO standards it is widely accepted that polypropylene pipe would be covered

PVC – Polyvinyl Chloride Pipe has the longest history of use of the thermoplastic pipe products. PVC has a respectable reputation for use in the sanitary sewer market. The sanitary sewer market has strict installation and inspection requirements. The storm sewer market currently has a much lower level of monitoring for installation and inspection. Will a product with a good reputation in a strictly controlled environment be able to perform satisfactorily in a less controlled environment? Are there sufficient procedures in place within the standards discussed below to ensure a successful installation?

Design
ASTM – N/A
AASHTO - Standard Specifications for Highway Bridges, Section 12 Section 12.12 covers the structural design of pipe products manufactured from PE or PVC

Manufacture
Important Elements of Specification

- Size range covered by specification
- Pipe stiffness allowed
- Wall profiles allowed
- Cell classifications required for resin
- Pipe and bell dimensions/tolerances
- Inspection, testing, and rejection criteria

AASHTO – M 304 Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Wall Drain Pipe and Fittings Based on Controlled Inside Diameter

- Size range covered by specification
- Pipe stiffness required
- Wall profiles allowed
- Cell classifications required for resin
- Pipe and bell dimensions/tolerances
- Inspection, testing, and rejection criteria

Installation

ASTM – D2321
AASHTO – Section 30

SPECIFICATION CHART
Attached as Spreadsheet