WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
DESIGN DIRECTIVE

DD-503
SELECTION OF PIPE MATERIALS
October 5, 2017

Attached is the West Virginia Department of Transportation, Division of Highways, Design Directive for the "Selection of Pipe Materials" to be used on all projects.

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This design directive is to provide guidance on the selection of appropriate pipe materials in terms of service life, hydraulic efficiency and structural capacity. The design process includes consideration of the factors shown in Section 1 through Section 5 below. Life cycle cost and safety shall take priority over initial cost. Small Corrugated metal pipe and pipe-arches may only be used for low volume roads with shallow cover heights. Galvanized structural plate pipe or pipe-arches installed with concrete paved inverts may only be used with the approval of the Director of the Engineering Division and the State Highway Engineer.

SECTION 1: ROADWAY CLASSIFICATION

The following table summarizes acceptable conduit materials based on the design classification, fill height, and service life requirement of the roadway that the pipe is to be placed under. Design classification is site specific rather than project specific and refers to the roadway that is directly over or supported by fill over the culvert.

Table 503-1
Allowable Pipe Materials

DESIGN CRITERIA	ALLOWABLE CONDUIT MATERIALS
Highways with an ADT ≥ 3000 or Height of cover ≥ 10 ft. 75 year design life	• Cast in Place or Precast Reinforced Concrete Box • Cast in Place or Precast Reinforced Concrete Arch • Reinforced Concrete Pipe and Elliptical Reinforced Concrete Pipe • High Density Polyethylene Plastic Pipe (solid wall, profile wall, or steel-reinforced), installed in Type F trench • Polyvinyl Chloride Plastic Pipe (profile wall), installed in type F trench • Polypropylene Plastic Pipe (profile wall), installed in type F trench
Highways with an ADT < 3000 and Height of Cover < 10 ft. 40 year design life	All of the above • High Density Polyethylene Plastic Pipe (solid wall, profile wall, or steel-reinforced) • Polyvinyl Chloride Plastic Pipe (profile wall) • Polypropylene Plastic Pipe (profile wall)
Highways with an ADT <400 and Height of Cover < 5 ft. 20 year design life	All of the above • Aluminized Steel, Type 2 Corrugated Metal Pipe, up to 24” • Aluminized Steel, Type 2 Corrugated Metal Pipe-Arch up to 66” x 51” • Galvanized Steel Corrugated Metal Plate Pipe-Arch, up to 128” x 83” • Aluminum Structural Plate Box Culvert

Unless otherwise specified, all pipes shall be installed in accordance with Standard Specification 604.

SECTION 2: HYDRAULICS

Hydraulic design of culverts is addressed in the WVDOH Drainage Manual.

SECTION 3: STRUCTURE

Refer to DD-502 for maximum cover and minimum cover for all pipes. The maximum values in DD-502 are conservative. The designer may exceed the limits set in DD-502 if the pipe is designed in accordance with AASHTO LRFD Section 12, *BURIED STRUCTURES AND TUNNEL LINERS*.

SECTION 4: CORROSION

Plastic pipe materials are acceptable in most environmental conditions without soil and water testing.

Concrete pipe will require resistivity and sulfate concentration. A resistivity of less than 1,000 ohm-cm is an indication of the presence of chlorides. As chlorides can attack the reinforcing steel, the reinforcing cage shall be epoxy coated. Sulfate content data is required for the use of concrete pipe.

Sulfate concentration is also a durability concern for concrete. Type II and Type V cement are designed to resist sulfate attack. However, Type V cement is not readily available, so Type II cement is generally used for precast concrete pipe. Reducing the water/cement ratio reduces permeability and is the single most important factor in increasing concrete resistance to sulfate attack. Increasing the cement content also improves sulfate resistance. Precast concrete pipe and box culverts are typically produced using 658 pounds (7 bags) of cement per cubic yard of concrete with a water cement ratio of 0.44 or less. Only a minor adjustment in the water cement ratio is required to meet the severe Sulfate condition. For very severe conditions the water cement ratio shall be reduced to 0.35. The following table illustrates the actions required for a given sulfate concentration. Cement content and water/cement ration shall be included in the plans when severe and very severe sulfate conditions are encountered.

Table 503-2
Sulfate Concentration For
Reinforced Concrete Pipe

Conditions			Requirements		
Relative Degree of Sulfate Attack	% Water-Soluble Sulfate in Soil Samples	PPM Sulfate in Water Samples	Cement Content (bags/cy)	Cement Content (lbs/cy)	Maximum Water/ Cement Ratio
Negligible	0.00 - 0.10	0 – 150	5	470	0.53
Positive	0.10 - 0.20	150 - 1,500	5	470	0.53
Severe	0.20 - 2.00	1,500 - 10,000	5.5	517	0.4
Very Severe	>2.00	>10,000	7	658	0.35

Metal pipes and structures are allowed as stated in table 503-1. pH of the water and soil must be between 5 and 9.

SECTION 5: ABRASION

The designer shall assess the abrasion potential for proposed culvert installations. Consider the slope of the stream and the size of the stream bed material. Determine the size of the streambed material in accordance with DD-409. Calculate the velocity of the flow in the channel upstream of the proposed culvert and in the proposed culvert to determine if the abrasive material in the streambed could be transported at a sufficient velocity to cause damage to the invert of the conduit. A 2-year storm (Q_2) shall be used to determine the velocity for abrasion potential. When flow velocities are greater than 25 feet per second, 6000 psi concrete and abrasion resistant aggregate are required.

There is a potential for higher than normal abrasion during construction due to runoff from disturbed areas that have not yet been vegetated or paved. For new construction projects, sediment traps shall be placed upstream of culverts to prevent large sediment from entering the culvert.

Three sided structures do not require invert protection, however, the potential for scour at the footings shall be addressed and documented. It may be less expensive to provide a concrete slab below the streambed between the footings instead of extending the footings to rock.

The following chart is to be used to select the appropriate invert protection for culverts. Use the velocity of the 2-year storm flow in the pipe or in the channel upstream of the pipe, whichever is greater.

Table 503-3
Invert Protection Chart
For Abrasive Flows

CULVERT MATERIAL	2-Year (Q_2) Storm Design Velocity			
	0 to 5 ft/sec	5 to 10 ft/sec	10 to 25 ft/sec	Greater than 25 ft/sec
Aluminized Steel Type 2	None	None	Concrete Paved invert	Concrete Paved invert
Aluminum Alloy	None	None	Add one gage	Add two gages
Galvanized Steel Plate	None	Paved invert	Concrete Paved invert	Concrete Paved invert
Plastic (PVC or HDPE or PP)	None	None	None	None
Reinforced Concrete Pipe	None	None	Aggregate with LA Abrasion loss of less than 30%	6000 psi concrete Aggregate with LA Abrasion loss of less than 30%